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HYDATID CYSTS OF THE LIVER

WITH REPORT OF SIXTY-THREE PREVIOUSLY UNPUBLISHED CASES

BY H. W. MILLS, M.R.C.S.(ENG.), L.R.C.P.(LOND.), F.A.C.S., SAN BERNARDINO, CALIFORNIA

IN man, 75 per cent of hydatid cysts occur in the liver. It is well to remember, in this connection, that man is not by any means a natural or satisfactory secondary host of the tænia echinococcus; also, that in various animals, such as the sheep, which *is* a natural and frequent host of this parasite, and which lends itself particularly well to the completion of the normal evolutionary cycle—the grand cycle in the alternation of generations, which is the rule, as opposed to the smaller and abnormal cycle, characterized by the vesicular transformation of the scolex, which is the only recourse of the parasite in man—it is not the liver, but the lung, which leads in point of frequency as a site for the larval stage.

Now, the main characteristic of echinococcosis is its extreme latency, and in the absence of complications, in the case of the liver, it is a symptomless enlargement of the abdomen which, for the most part, draws the patient's attention to the fact that anything is wrong; for until complications arise, the general health of the patient is usually excellent.

Here, then, it will be necessary to consider, somewhat in detail, only certain sequelæ, which from time to time occur, rendering the necessity of active treatment patent to both patient and medical attendant. When the cyst has attained a certain size, pressure symptoms occur, but such are in no wise peculiar to tumors due to the tænia echinococcus.

In any article dealing with this subject, it will be noted that the most frequently quoted authority will always be Dévé of Rouen, for there is scarcely an aspect of this disease which has not been elucidated in a masterly way by this man, by common consent recognized as the greatest living authority on the subject: the *securus judicat* argument in this connection is not likely to be disputed.

The commonest complications of hydatid cysts of the liver in man are multivesiculation and suppuration, and next comes intraperitoneal rupture. Thereafter, *longo intervallo*, one notes rupture into the bile channels, with or without concomitant lesions in the latter. Worthy of mention also are postoperative hydropneumocyst and pyopneumocyst, following the adoption of the closed technique. These will be briefly discussed *seriatim*.

Generally speaking, most hydatid cysts of the liver start in childhood; the fact that they are not noticed for 20 years or more is usually due to the slowness of their growth. Thus, when wishing to study the young, fresh, simple hydatid cyst, we go to the young patient, but rightly expect to find complications in those of more mature years.

MULTIVESICULATION AND SUPPURATION

Multivesiculation is an evidence of age or trauma; in brief, it is a defense reaction, an effort having in view the propagation of the

species. The primary host, be it dog, cat, wolf, or jackal, is not likely to enjoy the opportunity of eating human livers. There is, however, a forlorn hope that it may be able to get at and ingest the scolices contained in daughter cysts, which gain access to the outside world by hydatidentérie, hydatidémèse, or external rupture of a human liver cyst.

Though suppuration is less common than it was in the days before tapping of hydatid cysts was taboo, or the necessity for early operation was as universally recognized as it is now, it is still the commonest complication of hydatid cysts of the liver. It usually occurs in multivesicular cysts. In the case of spontaneous suppuration, the infection is biliary, and comes via the perivesicular space, some fissuring of the cuticle having occurred from trauma. In the young, even with large cysts, both multivesiculation and suppuration are rare, occurring as they do in less than 10 per cent of such cases. The obvious lesson to be learned is the necessity for early diagnosis and, consequently, early operation.

Cignozzi states that suppuration obtained in 20 per cent of his 50 personal cases of hydatid cysts of the liver, that it is commoner in acephalocysts (12 per cent) than in fertile ones (8 per cent), and that it explains the absence of eosinophilia. In his cases the complement fixation test and Casoni were negative also. He notes the frequency of albuminuria in such cases, and states that the serological tests fail when osmosis and diapedesis are impossible, that is, in cysts dead, degenerating or suppurating, very old, or calcified. He has never seen hydatid fremitus, and prefers marsupialization, packing daily, and making no attempt to remove the membranes. The mortality in his entire series of 50 operative cases, clean or suppurating, was 4 per cent.

Lauriol bases his thesis on 166 cases in Arabs, 46 of which were suppurating, that is, 29 per cent. He notes that it is the old, large, complex cysts which suppurate. Following Brun and Braquehaye, he has adopted the closed method of operation for suppurating hydatid cysts of the liver, and appends a list of 22 cases so treated: of these, 18 were cured, 1 died (from bronchopneumonia; patient operated on *in extremis*), and in 3 the recovery was retarded by complications unconnected with the cyst. He states that 80 per cent of cures are obtained by this method, in from 10 to 20 days. He remarks that suppuration can often not be diagnosed before operation, and is an extreme advocate of the closed method, advising, *pace* Lecène, against drainage even "in the presence of fetid pus, in febrile cases presenting all the clinical characteristics of a septic suppuration." He omits the anchorage of Posadas.

INTRAPERITONEAL RUPTURE

The intraperitoneal rupture of hydatid cysts of the liver is now recognized as being the most frequent complication next to suppuration. It occurs in some 18 per cent of such cases.

Pace the older writers from Hippocrates to Davaine, the immediate prognosis is not necessarily bad, though this remark does not apply to the ultimate results, i.e., multiple secondary abdominal echinococcosis, which is far from uncommon, and of which the results are extremely serious. The grafting of scolices was proved experimentally by Alexinsky in 1898, but the frequency of this occurrence in man was not generally accepted by the profession until after the publication of Dévé's article on secondary echinococcosis in 1901.

The hydatid seeds, sown on rupture of the cyst, do not always develop, and the only result of such insemination may be pseudotuberculous echinococcosis of the peritoneum (an abortive form of secondary echinococcosis), or the hydatid choleperitonitis of Dévé.

Alsina, writing on this latter complication, reports a personal case in a boy aged 9, in whom convalescence was interrupted by a pyopneumocyst of the right lobe of the liver. The condition was correctly diagnosed before operation; incidentally, hydatid fremitus was noted. He refers to articles on the subject by Villegas and C. Lagos Garcia, and quotes Dévé's definition of hydatid choleperitonitis as "an abdominal effusion, coming on slowly, following the collection in the abdominal cavity of non-virulent bile, resulting from the rupture of a hydatid cyst of the liver, the

collection being separated from the viscera by 'membrana fibrinocruorica.'"

While the immediate results are usually benign, in fact frequently overlooked, sudden death may occur from anaphylaxis, or a slower fatal issue from suppurative peritonitis following the rupture of even a clean cyst may occur from biliary infection.

While pseudo-tuberculous echinococcosis represents an action of defense of the organism against the disseminated echinococcic elements, it is not invariably a proof of cure, for subsequent evolution of these minute hydatid cysts may obtain.

In the case of hydatic choleperitonitis, ultimate cachexia and death occur in untreated cases. Secondary suppuration of the ruptured mother cyst may obtain.

The direct mortality of rupture in these cases is around 13 per cent.

It is well to remember that many of the cysts of the pelvic organs (prostate, uterus, ovaries, etc.), which are commonly regarded as primary, are, as a matter of fact, really examples of secondary peritoneal cysts which have barged in, and become incorporated with these organs. Multiple primary abdominal hydatid cysts are very rare.

The obvious lesson is that all hydatid cysts of the liver should be operated upon early, and use should be made of formolage if rupture has not already occurred. If it has, abdominal lavage with ether should be adopted.

BILIARY ELIMINATION OF HYDATID DÉBRIS, AND RESULTING GALL-BLADDER LESIONS

The hydatid débâcle occurs in from 5 to 10 per cent of hydatid cysts of the liver, and is probably responsible for the occurrence of some 33 per cent of the cases in which spontaneous gaseous suppuration results.

Duprey discusses the ultimate spontaneous cure of hydatid cysts of the liver in which elimination, usually fractional, via the bile ducts, has obtained. He is pessimistic as regards the satisfactory end-results in such cases, except in cases in which a single intact mother cyst has been passed—a rare eventuality.

Though Calcagno and Hue have reported cases of this kind with a happy termination, notwithstanding the fact that angiocholitis appeared as a complication in the patient of the former author, Duprey strongly advocates early (two-stage) operation, except in the unusual eventuality above noted. The technique of such operation should include clearing of the common duct, verification of the contents of the gall bladder, and a direct attack on the original hepatic cyst.

Hydatidentérie, which is easily overlooked unless methodical sifting of the stools is insisted on, is usually good evidence of the elimination of daughter cysts via the ampulla of Vater, though it may result from direct rupture into the gastro-intestinal tract of a cyst of the liver, or less frequently of the spleen.

Hydatidémèse, paroxysmal pain, and repeated attacks of jaundice (in 80 per cent of cases) are other symptoms, and the "hydatid accordeon liver" is often noted (14 per cent of cases).

Dévé noted the frequency of dilatation of the gall bladder, continued or intermittent, in two-thirds of the cases in which hydatid obstruction of the common duct obtained; also, the variable nature of the gall bladder contents in these cases, which is the same as that of the dilated duct (bile, pus, hydatids, concretions), when the gall bladder communicates freely with the common duct, but when the cystic duct is obliterated, empyema or more often mucocele is found. Para-hydatid lithiasis may obtain.

No authentic case of primary hydatid disease of the gall bladder has been recorded, with the possible exception of that recently reported by Astériadès, though a careful perusal of the author's description leaves one in doubt as to whether the site here was not primarily paravesicular: theoretically, of course, a primary hydatid cyst in the wall of the gall bladder itself is possible. Neither is there any record of a primary persistent localized obstruction of the hepatic duct, though secondary invasion by reflux from a distended common duct is frequent. Dévé has pointed out that the cyst would have to obtain in the walls of the gall bladder in the first instance, though it might subsequently rupture into the cavity.

Up to 1919, 22 cases of secondary hydatid obstruction of the cystic duct, in 13 of which the block was in its terminal portion, had been reported. Forty-two per cent of cysts evacuated in this way are situated in the silent zone. Opening into the gall bladder occurs in 6 per cent of cases, into the larger intrahepatic ducts in 90 per cent, and into the common bile duct in 1 per cent only.

The most important complications are suppurating angiocholitis; secondary opening of the original cyst into the pleuropulmonary apparatus; and secondary suppuration of the parent cyst, often putrid, which in 10 per cent of such cases assumes the clinical type of spontaneous pyopneumocyst of the liver. Involution, going on to septic mummification and multivesiculation of its contents are commonly seen in the parent cyst.

Vide also articles on this subject by Sasse, Tuffier, Quénu and Duval, Oliver, Berard and Cavaillon; works by Quénu, Dialti, Ratto, Castex, and Lecène and Mondor: theses by Carle and Cauchoix. During the war, two theses appeared, by Abadie, and Hernandez, and subsequently articles by Chauffard, Gouget, Dévé, Mathieu and Villard, Duprey, and Delamare, on the same subject.

In commenting on the treatment of these cases, Dévé contrasts the French and Argentinan techniques for operation in hydatid cysts of the liver opening into the bile ducts. He admits that Finochietto's arguments have forcibly impressed him, and that in the presence of a manifest and get-at-able cyst, especially if one suspects suppuration, which occurs in 55 per cent of cases, he, too, would commence by evacuating and draining the cyst, and there hold his hand, leaving for a second intervention on the common duct those cases where angiocholitic phenomena persist and demonstrate poor drainage.

Prat and Piquerez, in an excellent résumé, note that until recently the condition has been more or less overlooked in South America, though well recognized since the time of Berthaut (1882) in Europe. *Vide* article by Escudero, case reports by Ruvertoni and Piquerez, Gourand, Quénu, Bouilly, and Finochietto (24), and the theses of Fernicola, Bello, and Lazaro. The authors have had 4 personal cases opening into the gall bladder. *Pace* Dévé cysts of the silent zone may cause external deformities (as also may amœbic abscesses in the same situation). Generally speaking, the authors prefer the Argentinan technique, i.e., tackling the parent cyst first, if it can be found, and advocate local anæsthesia whenever possible. They tabulate 17 operative cases.

Bergareche reports a case of hydatid cyst in the silent zone of the liver, opening into the bile ducts, which was diagnosed before operation, in spite of a negative Casoni and absence of hydatidentérie. Multiple infected glands were found around the neck of the gall bladder and in the hepatic hilus. Successful two-stage operation was performed.

HYDROPNEUMOCYST FOLLOWING OPERATION BY THE CLOSED METHOD

The possibility of the occurrence of this complication does not militate against the closed method. The prognosis is good; all Dévé's 15 cases recovered. He points out that the gas is the first and most essential element in the symptomatology.

It is well to look out for symptoms on the fourth day. The gas is absorbed in 30 to 40 days. The effusion may recur after tapping, it always persists longer than the gas (6 weeks to 8 months).

Tapping is sufficient by way of treatment and establishes the diagnosis between hydropneumocyst and pyopneumocyst. Drainage is unnecessary, except in the presence of fetid suppuration.

The following is a typical case report (Dévé and Ducros). Hydatid cyst of the liver. Formolage with 500 grams of 5 per cent strength. Three liters of fluid were aspirated, and the daughter cysts evacuated. The sac was mopped with 5 per cent formalin compresses. Electric illumination of sac showed no bile. Closure was done without drainage, and contained air aspirated. On the fourth day a sonorous zone appeared, and X-ray demonstrated gas. On the nineteenth day, the pouch was tapped, and brownish non-fetid bile-stained liquid, with much odorless gas, escaped. The patient was discharged 10 days later.

As a prophylactic, the method of filling the sac with normal saline solution, as practiced by various Australian surgeons (Zwar, Hamilton Russell, etc.), immediately suggests itself.

PYOPNEUMOCYST

To Dévé, again, we must mainly go for instruction. Of his 69 collected cases, 2 were excluded as being examples of echinococcosis bavaro-tyrolienne, and 11 more as being questionably spontaneous. Of the 56 cases left, 13 were associated with elimination of hydatid débris via the bile ducts, and 10 more probably so, i.e., the association was noted in certainly 24 per cent, and probably in 41 per cent of cases.

Dévé regards the hydatid débâcle as the etiological factor in one-third of such cases, the symptoms of which are violent and sudden abdominal pain, with or without fainting, vomiting and rigors, followed or not by jaundice and the rapid augmentation of the hepatic tumefaction.

The site of cysts exhibiting this complication is usually the silent zone of the liver (posterolateral region of the right lobe); and the prognosis, untreated, practically hopeless, though one cure has been reported by Guillermin.

The origin of the gas is autochtonous from local anaerobic infection of biliary origin (Gilbert and Weil). Marsupialization, preceded by formolage (for daughter cysts may live in a bath of pus), is the best treatment; the mortality is around 55 per cent.

Postoperative persistent external cholerrhagia should suggest obstruction of the common bile duct by hydatid débris.

Dekester and Martin refer to the frequency of hydatid disease in Morocco, and report, among others, 12 cases of the liver.

Verger, Papin, Piéchaud, and Daraignez report a case of multiple and complicated hydatid cysts of the liver. The patient was a woman aged 24, with a hard, bosselated tumor, the size of 2 fists, in the left lobe of the liver. The appearance suggested a neoplasm. Puncture of the bosselations cleared up the diagnosis. At operation, 15 of the hydatid cysts had been treated by formolage and incision, when a large cyst, stuffed with daughter cysts, came into view. This was excised, and the large cyst formolized and marsupialized. The margin of the liver was filled with numerous cavities. Hooklets were demonstrated. Recovery ensued. The explanation is multiple independent hydatid cysts, or exogenous vesiculation, such as is observed in osseous echinococcosis, but is elsewhere very rare in man.

Urrutia states that Spain is the most hydatid infested country in Europe, and that the disease is now common in the Basque country, where it was rare until 10 years ago. He contrasts the good general condition of patients harboring clean cysts with the hydatid cachexia of those with suppurating cysts, and refers to the "hydatid infantalism" of Dévé.

Discussing hydatid fremitus, he states that he has seen it on 5 occasions, 4 times in cases of hydatid cysts (1 of kidney, 1 of omentum, and 2 of liver), and once in an ordinary ovarian cyst operated on by Oreja. He regards its diagnostic value as small, since it has also been noted in hydronephrosis (Rolleston), in cysts of the mesentery (Hoppe-Seyler), in a cystadenoma of the liver (Landau); moreover, he reminds us that Mandinaveitia repeatedly saw it in cases of ascites.

He quotes Fairley to the effect that there are many more painful hydatid cysts of the liver than has been previously supposed. He notes the occasional difficulty in the differential diagnosis between insidiously suppurating hydatid cysts of the liver and carcinoma, and resorts to exploratory puncture in such cases. He points out the folly of attempting "enucleation," and remarks that in Spain marsupialization is the most used method, even for clean cysts. He advocates formolage, and notes in regard to calcification that Randavel could collect only 8 cases. Incidentally, Mariantschik has recently reported an instance of this complication.

Pujol remarks that the disease is very common in Salamanca. He has personally studied 58 cases, of which 47 have been operated upon. Icterus obtained in 11. In a most interesting article he elucidates the etiological mechanism of the production of icterus in these cases, under the following headings:

1. Rupture of a cyst into the bile ducts with hydatid pseudo-lithiasis.

2. Extrinsic compression of the ducts by the cyst itself, especially cysts situated in the quadrate lobe of the liver, and the lobe of Spiegel. Many of the cases of cysts of the gastrohepatic omentum and the foramen of Winslow have an hepatic origin.

3. Infective complications in or around the cyst, e.g., enlarged glands on the hilus of the liver.

Bachlechner reports a case which was operated upon with the diagnosis of calculus block of the choleduct. At operation the choleduct was found to be dilated to the size of the duodenum. It was incised, pus and hydatids escaped. A suppurating hydatid cyst, containing daughter cysts, was found in the right lobe of the liver. This was drained, and the choleduct sutured. Death from coma occurred on the third day. He quotes 2 cases of Sasse, which were cured by this technique. When the choleduct in such cases is incised, extreme precautions must be taken to protect the operative field from contamination.

Calcagno refers to his 2 previously published cases in which spontaneous cure resulted (Bello's thesis was based on these 2 cases and 9 others reported by Viñas and Arce). He denies the soft impeachment (*vide* the thesis of Duprey) that he was guilty of initiating a reaction against the surgical treatment of these cases. All he questions is the urgency of intervention, all he pleads for is "armed expectancy." He insists that the "size of the cyst is of no importance, what does matter is the amount of infection."

R. Finochietto, in discussing the subject of hydatid cysts of the liver opening into the bile ducts, writes: "I know of no case in which, when it has been clearly shown that marsupialization is insufficient, subsequent drainage of the common duct has saved the situation. The converse has frequently obtained. The observation of Dr. Ceballos is interesting, in that it is the first case among us in which drainage of the common duct was sufficient in itself to cure the patient. The procedure was justifiable here because it was easier to drain the common duct than to drain a cyst situated in the lobe of Spiegel."

Castex, Romano, and Beretervide discuss hydatid cysts of the liver of the pseudo-lithiasis type, and quote Tuffier to the effect that in a case of chronic jaundice with a history of hepatic colic, and the picture of lithiasis in a healthy subject, one should always think of, and look for a hydatid cyst in the Spigelian lobe. They report a typical case, and refer to others published by Di Giovini, Pesci, Oliver, Chauffard, and Gouget. They quote Agote, Escalier, and Ansa of Argentina in reference to cases of hydatid cysts of the liver simulating lithiasis without opening into the bile ducts.

H. Costantini describes his thoraco-phreno-laparotomy without pneumothorax in the surgical treatment of hydatid cysts of the liver situated in the silent zone.

The recent radiological technique in which lipiodol is injected into the biliary tree through a postoperative fistula for diagnostic purposes is discussed by Cotte, Dévé, and Lefèvre and Monties.

Nafi-Subai and Hovaguimian report the case of a native woman of Dier-ez-Zor, Syria (hydatids are rare in Northern Syria), in whom 11 hydatid cysts of the liver, the size of mandarins, all easily "enucleated," were found at operation. She was discharged cured in 11 days. He points out that although hydatid cysts of the liver are multiple in 33 per cent of all cases (Dévé), nevertheless 11 is an unusual number.

F. D. Bird notes the fact that congeries of small marginal hydatid cysts of the liver may simulate malignant or syphilitic hepatic disease, and that it is exceptional for a hydatid cyst to be entirely surrounded by liver tissue. He states that rupture into the gall bladder is very rare, and that hydatidémèse presupposes a pathological gastric basis. In the liver the adventitious capsule may be the site of carcinomatous or amyloid degenerations. If the patient has expectorated daughter cysts, the odds are equal on the parent cyst being in the liver or the lung. He thinks that Fairley has exaggerated the frequency of pain in hydatid cysts of the liver, many of which appear to barely maintain their lives for very long periods, 26 years in one of his cases. A rise of temperature does not necessarily indicate

suppuration. It may occur in rapidly growing clean cysts. He thinks that some of the so-called "simple cysts" of the liver may have an echinococcic origin, acephalocysts having died from excessive fibrosis, with loss of all traces of their membranes. He thinks that toxicity of the contents is more likely to obtain in daughterless cysts, and leans toward marsupialization by way of treatment.

Colucci describes a herniated hour-glass shaped hydatid cyst of the liver, the size of a large pear, with turbid contents and daughter cysts, recurring in a laparotomy scar in a woman aged 52. Her first operation was 12 years ago. The complement fixation test was negative, and eosinophilia 1 per cent. Marsupialization and drainage was performed. A biliary fistula resulted, but ultimate cure obtained. The symptomatology was that of hepatic colic with temporary obstruction, the bile ducts had been compressed extrinsically by the cysts or blocked by daughter cysts. He notes that the X-ray is not so useful in the case of hydatid cysts of the liver as it is in hydatid cysts of the lung. In this connection, see Arnold's article on the diagnosis of hydatid cysts of the liver by means of the roentgen-ray.

Partsch, in an exhaustive article on the subject of echinococcosis of the liver, concludes:

1. Clean cysts should be treated by formolage and closure, but if infection does occur, healing is slower than if formol had not been used.

2. Filling the empty sac with formol and abandoning it gives similar results to primary suture of the empty sac: transitory kidney disturbances may occur.

3. The closed technique should be adopted when possible, including the anchorage of Posadas.

D. S. Cúneo deplores the fact that in Entre-Rios in the last 20 years, out of 52 cases treated, the Posadas method was adopted only 3 times, whereas it should have been practiced in 50 per cent of the cases. He approves of the use of Finochietto's trocar-aspirator, applied *after* formolage of the cyst.

INCIDENCE IN NORTH AMERICA

In North America the number of hydatid cysts of the liver reported (alone, or coincidental with other intra-abdominal hydatid cysts) up to the time of the publication of Lyon's statistics (January, 1902) was 177. Since that time to date, 135 more case reports have appeared.[1]

To these I here add a brief résumé of 63 hitherto unpublished cases. This brings the total to date for North America up to 375, a relatively small number, but then the disease, fortunately, is relatively uncommon in this country.

In addition, there is little doubt but that the disease in Case 12 of Davis and Balboni's statistics originated in the liver. The same remark applies to Case 12 (spinal cord—ex liver), and Case 23 (gall bladder) of T. B. Magath, for Dévé has shown that primary echinococcosis of the gall bladder does not occur. Another dubious case is that reported by L. F. Barker. The size of the cysts was considerable in this case, and, according to Dévé, the finding of a single free daughter cyst negatives the diagnosis of echinococcosis bavaro-tyrolienne.

The inclusion of these last 4 cases would, with the cases here reported, bring up the grand total to 379.

CASE REPORTS

CASE 1. (Courtesy of Dr. B. F. Alden, San Francisco.) Hydatid cyst of the liver, containing daughter cysts, in a Frenchman. Operated upon in the French Hospital in 1910. Marsupialization and drainage. Recovery.

CASE 2. (Courtesy of Dr. B. F. Alden, San Francisco.) Italian woman with two separate hydatid cysts of the liver, 1 the size of an apple, the other the size of a tangerine. Primary closure after cleaning out the contents. Healing by first intention. No daughter cysts obtained in either of the cysts.

CASE 3. (Courtesy of Dr. C. B. Alexander, Alhambra, California.) Hydatid cysts of the liver, omentum, and pelvis in an American woman aged 50, who had lived in Illinois until 1912, and subsequently in California. Liver had troubled her since childhood. The liver cyst had ruptured during abdominal manipulation by a previous attendant, and an emergency laparotomy had to be done in shock by Dr. Alexander (1918). Death occurred in 14 hours. The cyst contained daughter cysts, and hooklets were demonstrated (Dr. Black).

CASE 4. (Courtesy of the late Dr. H. P. Barton, Los Angeles, 1907.) Hydatid cyst of the liver in a Russian male, who had lived several years in America. Operation: marsupialization and drainage (Dr. A. J. Saylin). Recovery. Hooklets were demonstrated (Dr. Black).

CASES 5 to 12. (Courtesy of the late Dr. S. P. Black, Los Angeles, 1902–1909.) Eight hydatid cysts of the liver, in all of which hooklets were demonstrated. All the cases came from Southern California. No further details obtainable, owing to the untimely death of Dr. Black.

CASE 13. (Courtesy of Dr. A. W. Blain, Detroit, 1914.) Hydatid cyst of the liver in a Greek male, aged 34, who had lived 3 years in America. Pain in liver had obtained for 1 year. Operation: marsupialization and drainage. Discharged cured in 7 weeks. Hooklets were demonstrated. Eosinophilia 2 per cent.

CASE 14. (Courtesy of Dr. A. W. Blain, Detroit, 1916.) Hydatid cyst of the liver in a Greek male aged 26, who had lived 5 years in America. Operation: marsupialization and drainage. Left hospital on the seventeenth day. Readmitted on the twenty-seventh day, and an ineffectual attempt made to remove the membranes. Prolonged convalescence and drainage. Mother cyst ultimately discharged. Recovery.

CASE 15. (Courtesy of Dr. F. Bortone, Jersey City, New Jersey, 1920.) Hydatid cyst of the liver in an Italian man aged 37, who had lived 2 years in America. Operated on 7 years before in Algeria for hydatid cyst of the liver. Operation: marsupialization and packing with iodoform gauze. The cyst was the size of a grapefruit; fluid clear. No daughter cysts. Hooklets were demonstrated. Recovery: 3 months healing.

CASE 16. (Courtesy of Dr. S. Bunnell, San Francisco, 1921.) Hydatid cyst of the liver, which had invaded the pleura, in an Icelandic male aged 68. Cyst wall and contents shelled out, and cavity drained. Embolism occurred at the base of the brachial artery a week later: artery opened, clot removed, and artery sewed longitudinally: death in 7 hours. This man had had a hydatid cyst of his liver drained 26 years previously. No eosinophilia obtained. No complement fixation test was done. Hooklets and laminated membrane were demonstrated.

CASE 17. (Courtesy of Dr. R. A. Campbell, Los Angeles.) Hydatid cyst of the liver, containing daughter cysts, in an American male aged 24, who had lived in Mexico. Operation, 1908: marsupialization and drainage. Recovery. No laboratory

[1] Oertel; Eliot; Lilienthal (3); Hartley (3); LeWald; Rogers; Hotchkiss; Stone; Porter; Murphy; Holmes (3); Halsey; Welch; Coe; Henry (6); Cheney (2); Garrett; R. S. Fowler (7); Barton; Ashton; Hayd; Brewer (2); D. F. Jones (2); McKechnie (8); Winthrop; Harnagel; Meyer; Syms; Fay; Helms; Vaughan; Hawkes (3); Johnston and Willis (2); Cahana; Phemister; Davis and Balboni (19); Romaine; Maj. H. W. Jones; Sherwood; Magath (22); DaCosta (2); Edelman; Friedlander; Dowd; Deming; Halstead; Young; Glassman; O'Connor; Pool (3); Campbell; Roan (2); Eliason; King; Brown (2); Cave; Heyd; Moschcowitz; Mills (3).

tests were done. This patient was quite well 10 years later.

CASE 18. (Courtesy of Dr. R. C. Chaffin, Los Angeles.) Hydatid cysts of the liver in an Armenian woman aged 30, who had lived 25 years in America. Operation, August 1, 1925: marsupialization and drainage. Many daughter cysts continued to discharge after operation. September 20, 1925, still some biliary discharge. Hooklets were demonstrated. Complement fixation test was negative. Casoni was not done. Fluid clear. No history of association with dogs.

CASE 19. (Courtesy of Dr. G. W. Clark, Michigan, 1905.) Hydatid cyst of the liver in an American man aged 30, from Toledo, Ohio. Operation performed by Dr. Harold C. Wyman of Detroit, in 1905: marsupialization and drainage. Recovery. The cyst was an enormous one, containing daughter cysts.

CASE 20. (Courtesy of Dr. W. B. Coffey, San Francisco, 1916.) Hydatid cyst of the liver in a Spaniard aged 42, who had lived 39 years in Spain, 1 year in Honolulu, and 2 years in America. Operation: marsupialization and drainage. In hospital 123 days: left with discharging sinus. Patient was subsequently lost sight of. Hooklets and scolices were demonstrated.

CASE 21. (Courtesy of Dr. W. B. Coffey, San Francisco, 1921.) Hydatid cyst of the liver in an American woman aged 69, from Michigan. Operation: marsupialization and drainage. Hooklets were demonstrated. Discharged from hospital on the seventeenth day with sinus closed. Five months later the patient was in good health.

CASE 22. (Courtesy of Dr. W. A. Downes, New York City, 1906.) Hydatid cyst of the liver in an Italian male. Died a few days after operation.

CASE 23. (Courtesy of Dr. W. A. Downes, New York City, 1920.) Hydatid cyst of the liver in an Italian woman. Operation. Recovery.

CASE 24. (Courtesy of Dr. R. S. Fowler, Brooklyn, 1911.) Infected hydatid cyst of the liver in an Italian man aged 35, who had lived for 15 years in America. Operation: marsupialization and drainage. Two gallons of purulent fluid, containing daughter cysts, removed. Recovery. Hooklets were demonstrated.

CASE 25. (Courtesy of Dr. R. S. Fowler, Brooklyn, 1911.) Hydatid cyst of the liver in an Italian man aged 21, who had lived in America for 4 years. Operation in two stages. Daughter cysts and hooklets demonstrated. Recovery. Recurrence 8 years later: further operation refused.

CASE 26. (Courtesy of Dr. R. S. Fowler, Brooklyn, 1916.) Hydatid cyst of the liver in an Italian man aged 21, who had lived for 10 years in America. Resection of ribs and drainage. Daughter cysts and hooklets demonstrated. Recovery.

CASE 27. (Courtesy of Dr. R. S. Fowler, Brooklyn, 1916.) Hydatid cyst of the liver in an Italian man aged 21, who had lived for 3 years in America. Operation: infected cyst under the surface of the right lobe of the liver near the gall bladder, marsupialized and drained. Daughter cysts and hooklets demonstrated. Recovery.

CASE 28. (Courtesy of Dr. R. S. Fowler, Brooklyn, 1918.) Multilocular hydatid cyst of the liver in an Austrian woman aged 46, who had lived over 5 years in America. Operation: cyst removed by cautery from under the surface of the right lobe of the liver. Very little hæmorrhage. Entire mass, which weighed 4 pounds 4 ounces, about the size of a pineapple. Patient died of operative shock.

CASE 29. (Courtesy of Dr. Jacob Frank, Chicago, 1922.) Hydatid cyst of the liver in a Russian woman aged 43, who had lived 24 years in America. Operation: marsupialization and drainage: cavity packed with gauze. Cyst contained about a gallon of fluid, and also daughter cysts. The fistula closed in 6 months. Complement fixation test and eosinophilia negative. Casoni was not done. Recovery.

CASE 30. (Courtesy of Dr. H. Garcelon, Victorville, Calif., 1905.) Hydatid cyst of the liver in a Mexican man, who had only been in the country 5 or 6 months. Operation: the cyst was the size of a grapefruit and contained daughter cysts. Marsupialization and drainage. Profuse suppuration and cachexia, from which the patient succumbed several weeks later. Under the care of Dr. Victor Rendon.

CASE 31. (Courtesy of Dr. G. L. Cole, Los Angeles, 1907.) Suppurating hydatid cyst of the liver in an Italian woman, who had lived only a few years in America. Operation: simple incision and drainage, as the cyst was adherent to abdominal wall. Hooklets were demonstrated (Dr. Black). Recovery.

CASE 32. (Courtesy of Dr. M. Isnardi, San Francisco, 1920.) Multiple hydatid cysts of the liver in an Italian man aged 35, who had lived for 20 years in America. No history of association with dogs. Operation: marsupialization and drainage of 6 hydatid cysts of the liver, the largest of which was about the size of an orange. Recovery. Eosinophilia 6 per cent.

CASE 33. (Courtesy of Dr. C. A. Jenson, Ventura, Calif., 1920.) Hydatid cyst of the liver in an American woman aged 60, who was born in Illinois, and who had never been out of America. Operation: marsupialization and drainage. Recovery. Hooklets and scolices were demonstrated (Dr. Black). Infection ascribed to a cat. No laboratory tests were made.

CASE 34. (Courtesy of Dr. W. J. Knox, Kelowna, B. C., Canada, 1912.) Hydatid cyst of the liver in a New Zealand man aged 45, who had lived for 6 years in Canada. Operation, 1912 (Dr. R. E. McKechnie): marsupialization and drainage. Recovery.

CASE 35. (Courtesy of Dr. V. R. Mason, Los Angeles, 1920.) Hydatid cyst in the right lobe of the liver in a Welshman aged 27, who had lived 12 years in America. Operation (Dr. G. J. Aguer, Baltimore): marsupialization and drainage. Prolonged bilirrhagia *ex vacuo*. Death from cachexia. At autopsy

one other cyst, the size of an orange, was found in the left lobe of the liver, clean. No hydatid cysts elsewhere.

CASE 36. (Courtesy of Dr. Thomas McHugh, Los Angeles, 1920.) Hydatid cyst of the liver in a woman aged 24, of American parentage, who had lived for 22 years in the Argentine. At operation the cyst, the size of a cocoanut, was accidentally ruptured during enucleation, which was very easy, as the cyst occupied the border of the liver. Biliary drainage for one month. Recovery. Eosinophilia 3 per cent. Hooklets and scolices were demonstrated (Dr. Black). Patient reported as quite well in December, 1921.

CASE 37. (Courtesy of Dr. J. F. Holleran, Los Angeles.) Calcified hydatid cyst of the liver in an Austrian woman aged 38, who had lived 16 years in America. The cyst was discovered during the course of an operation for chronic appendicitis, when the gall bladder was examined. Excision and suture of the liver was performed. Discharge of bile continued for 5 weeks. Recovery. Daughter cysts, hooklets and laminated membrane were demonstrated.

CASE 38. (Courtesy of Dr. F. R. Mugler, San Luis Obispo, Calif.) Hydatid cyst of the liver in an American man aged 30, who was accustomed to sleep with his dog on the bed. Operation: marsupialization and drainage was performed (1925). On the twenty-second day, copious brick-dust colored fluid still continued to discharge. Recovery. A single scolex was demonstrated. No eosinophilia.

CASE 39. (Courtesy of Dr. O. L. Norsworthy, Houston, Tex.) Postmortem case (1908) of hydatid cyst of the liver in an Italian man aged 40. Hooklets were demonstrated.

CASE 40. (Courtesy of Dr. O. L. Norsworthy, Houston, Texas, 1896, not included in Lyon's statistics.) Postmortem case of hydatid cyst of the liver in an Italian man aged 35. Hooklets were demonstrated.

CASE 41. (Courtesy of Dr. O. L. Norsworthy, Houston, Texas, 1911.) Multiple hydatid cysts of the liver in a Polish Jew, who was born in America, but had traveled extensively abroad. Operation: marsupialization and drainage. Profuse discharge followed. The patient died 3 months later from exhaustion. Hooklets and laminated membrane were demonstrated.

CASE 42. (Courtesy of Dr. H. F. Rand, Los Angeles.) Multiple hydatid cysts of the liver in a Portuguese woman aged about 35, who had lived for many years in Napa Valley, Calif. Operation: marsupialization and drainage. One large cyst found attached to under side of liver, and a number of smaller ones. Hooklets were demonstrated. Good recovery.

CASE 43. (Courtesy of Dr. H. F. Rand, Los Angeles.) Hydatid cyst of the liver in a Portuguese woman aged about 35, who had lived for 12 years in America. Operation: marsupialization and drainage. Hooklets were demonstrated. Good recovery.

CASE 44. (Courtesy of Dr. H. F. Rand, Los Angeles.) Hydatid cyst of the liver in an American man aged 30, who had lived in the Philippines for 5 years. The tumor started before he returned to the United States, and was very large when operated upon. Abdomen greatly distended. Operation: sac, from which 25 pounds of fluid was removed, attached to under side of left lobe of the liver, marsupialized and drained. Recovery slow. Hooklets were demonstrated.

CASE 45. (Courtesy of Dr. Emmet Rixford, San Francisco, 1920.) Hydatid cysts of the liver and abdomen in a Serbian woman aged 50, who had lived in California for 14 years. Operated on in Fresno in August, 1913, and again in 1918. Operation, August 2, 1920: multiple omental and abdominal hydatid cysts. Large hydatid cyst on under surface of liver. One gallon of cysts, some as large as a fist, removed. Death. No postmortem. A sister in Serbia had had hydatid disease.

CASE 46. (Courtesy of Dr. G. D. Scott, Sullivan, Indiana, 1922.) Multiple hydatid cysts of the liver in an American woman aged 55, who had always lived in Indiana. Illness started 22 years ago. Growth noticed 6 years ago. Operation: resection of the portion of the liver containing one cyst, the size of an orange, and several smaller ones. Closure without drainage. Hæmorrhage stopped by suture. Tumor appeared to involve the entire liver, and was composed of cysts the size of a pin's head to an orange. Most of the liver tissue was destroyed. Scolices were demonstrated. Recovery from operation.

CASE 47. (Courtesy of Dr. N. F. Sprague, Los Angeles, 1916.) Hydatid cyst of the liver in an English sailor aged 25, who was temporarily in port. The cyst was tapped. It contained daughter cysts, and hooklets were demonstrated. The patient refused further operation, and was subsequently lost sight of.

CASE 48. (Courtesy of Dr. W. H. Stiles, San Bernardino, Calif.) Hydatid disease of the liver in an American born woman aged 25, of German parentage. During her pregnancy, she complained of much abdominal pain, and suffered from jaundice. Large tumor of liver. Labor at full time, normal child born and lived. Six days later, high temperature and tympanites supervened, and 2 days later a large number of daughter cysts, in which hooklets were demonstrated, was discharged per rectum. Seven days later she died of septic peritonitis. No postmortem.

CASE 49. (Courtesy of Dr. C. T. Sturgeon, Los Angeles, 1925.) Hydatid cyst of the liver in an Italian woman. Operation: manual enucleation à la Posadas. Severe and persistent hæmorrhage and death. Cyst was attached to diaphragm.

CASE 50. (Courtesy of Dr. M. G. Sturgis, Seattle, 1907.) Hydatid cyst of the liver in a male adult. Nationality not known. Case under the care of Dr. Horton. Operation: marsupialization and drainage. Recovery. Hooklets were demonstrated.

CASE 51. (Courtesy of Dr. M. G. Sturgis, Seattle, 1908.) Hydatid cyst of the liver in a male adult. Nationality not known. Case under the care of Dr. Horton. Operation: marsupialization and drainage. Recovery. Hooklets were demonstrated.

CASE 52. (Courtesy of Dr. M. G. Sturgis, Seattle, 1920.) Multiple hydatid cysts of the liver, 10 on upper surface, and 6 on lower surface of right lobe, in an Italian man aged 38, who had lived for 10 years in America. Eosinophilia 6 per cent before operation: disappeared after. Operation: marsupialization of main cyst, through which the others were evacuated. At least one-third of the liver was destroyed. Prolonged discharge. Rapid cure after X-ray therapeusis. Many daughter cysts obtained, and hooklets were demonstrated.

CASE 53. (Courtesy of Dr. C. Toland, Los Angeles, 1922.) Hydatid cyst of the liver in an Englishman aged 76, who had always lived in America. The cyst, which was multivesicular, was drained under local anæsthesia. The patient died on the third day from pneumonia.

CASE 54. (Courtesy of Dr. O. Westerfeld, San Francisco, 1924.) Multiple hydatid cysts of the liver in a Slavonian woman aged 22, who had lived for 5 years in America. Operation: incision and drainage, May 5, 1924: 300 cubic centimeters of clear fluid evacuated. The cyst, the size of an orange, was situated deep in the liver tissue. Several smaller cysts were found, the contents of some of which were turbid. Hooklets and scolices were demonstrated. Eosinophilia 11 per cent. The patient made a rapid recovery, and has since remained well (October 10, 1925).

CASE 55. (Courtesy of Dr. Paul Bresee, Los Angeles, 1900, case not included in Lyon's statistics.) Hydatid cyst of the liver in a German man aged 45, who had lived many years in America. Patient expectorated bile and hooklets for some months. This was a case of hydatid cyst of the liver discharging by way of the bronchi, with ultimate spontaneous cure.

CASE 56. (Courtesy of Dr. Paul Bresee, Los Angeles, 1902, case not included in Lyon's statistics.) Hydatid cyst of the liver in an American man aged 43. Symptoms and evolution similar to those in case 55. Here also ultimate spontaneous cure resulted.

CASE 57. (Courtesy of Dr. Paul Bresee, Los Angeles, 1896, case not included in Lyon's statistics.) Suppurating hydatid cyst of the liver in a male foreigner aged 55, the duration of whose residence in America was unknown. He died with a diagnosis of abscess of the liver, and at autopsy a suppurating hydatid cyst of the liver, containing daughter cysts, was found.

CASE 58. (Courtesy of Dr. T. A. Williams, Pasadena, California, 1913.) Suppurating hydatid cyst of the liver in an English sailor, about 50 years of age, who had lived in Alaska. Operation: marsupialization and drainage. Many daughter cysts. Recovery. This patient died in 1921, following an operation for suppurative cholecystitis. No postmortem.

CASE 59. (Courtesy of Dr. T. A. Williams, Pasadena, California, 1914.) Clean hydatid cyst of the liver in an American man, between 50 and 60 years of age, who had been a shepherd in California, and subsequently a miner in Alaska. The cyst was tapped and drained through the thorax. Recovery. Patient subsequently lost track of.

CASE 60. (Courtesy of Dr. T. A. Williams, Pasadena, Calif., 1918.) Clean hydatid cyst of the liver in a man between 50 and 60 years of age, of unknown nationality. The duration of his residence in America is not known. Operation: marsupialization and drainage. Recovery. Died 2 years later from abdominal recurrence

CASE 61. (Courtesy of Dr. J. E. Engstad, Grand Forks, N. D., 1906.) Hydatid cyst of the liver, containing 500 cubic centimeters of fluid and daughter cysts, "enucleated" from an Armenian woman aged 40, who had lived about 15 years in America. Recovery.

CASE 62. (Courtesy of Dr. J. E. Engstad, Grand Forks, N. D., 1905.) Hydatid cyst of the liver in an Icelandic man aged 45, the duration of whose residence in America is not given. Emergency operation for hydatid cyst of the liver, which had ruptured into the general peritoneal cavity and which contained many daughter cysts. Death from anaphylaxis.

CASE 63. (Courtesy of Dr. C. B. Harris, Pembina, N. D., 1906.) Enormous hydatid cyst of the liver extending down nearly to the pubes, and containing many daughter cysts, in an Icelandic man whose age is not given. Icterus. Operation: marsupialization and drainage. Recovery.

SUMMARY OF CASE REPORTS

Of these 63 cases, 39 were from California, and 24 from other states. New York supplied 7; Michigan, 3; North Dakota, 3; Washington, 3; Texas, 3; New Jersey, 1; Maryland, 1; Illinois, 1; Indiana, 1; and 1 came from Canada.

Close association with animals as a possible etiological factor was noted in Case 38 (dog), and in Case 33 (cat).

Nationality. In 12 cases the patients were stated to be indigenous Americans, but one of these (Case 36, aged 24) had lived in the Argentine for 22 years. In another case (17) the patient lived for some time in Mexico, and in a third case (44) he had resided in the Philippines.

Thirty-nine occurred in foreigners: the duration of residence in America being given in years as 3, 5, 2, 25, 2, 10, 4, 15, 3, 5, 24, "a

few years," 20, 12, "many years," 16, 12, 14, 10, 5; in 13 cases it was not noted. One case (53) was that of a man aged 76, who had lived all his life in America. In another case (41), the patient was born in America, but had lived most of his life abroad. In 11 cases the nationality was not mentioned.

In one case (46) the duration of the disease was definitely stated to be 22 years. In another, that of a patient aged 50, there was a definite history of "liver trouble" since childhood.

Laboratory tests. Eosinophilia was increased to 11 per cent in Case 54, and to 6 per cent in Cases 32 and 52. It was definitely stated that it was not above normal in 5 cases, (13 16, 29, 36, 38). Eosinophilia 1 to 3 per cent is here regarded as normal.

No mention was made in any of the cases of the Casoni intradermal test having been used. In 2, the complement fixation test was negative (Cases 18 and 29).

Condition of cyst. Suppuration was frank in Cases 24, 26, 27, 57, and 58. In another case (54) the fluid was stated to have been turbid. Multivesiculation obtained in 22 cases, and in 1 of these (Case 48) hydatidentérie was noted. Hooklets were demonstrated in 41 cases, and laminated membrane in 4 cases.

Family echinococcosis. In one case (45) a sister of the patient had had hydatid disease, and in another (46) a cousin had been operated on several years previously for hydatid cyst of the spleen.

Treatment. Thirty-seven cases were treated by marsupialization and drainage; one case (2) by the classical closed method; in 3, excision *en masse* was the technique adopted, by cautery in Case 28, by excision and suture of the liver in Case 37, in Case 46 by resection of the area of the liver containing the cyst, and in Case 61 by "enucleation." In one patient, a recent rupture of the liver cyst had occurred, and cysts of the omentum and pelvis also obtained—evidence of a previous rupture. One Case (27) was tapped only, the patient declining further operative treatment. The technique was not given in 2 cases (22 and 23). Cases 39, 40, and 54 were postmortem specimens, and in Cases 5 to 12 inclusive no details were obtainable, beyond the facts that they all came from Southern California, and that hooklets were demonstrated in all of them. No operation was performed in the one case in which hydatidentérie was noted. Spontaneous cure was noted in Cases 55 and 56, in which cysts originating in the liver were evacuated via the bronchi. In one case, manual enucleation was attempted (49): the patient died from shock and hæmorrhage. In one case (53) the cyst was drained under local anæsthesia, on account of the poor general condition of the patient.

Previous operations had been performed for echinococcosis in Cases 3, 15, 16, and 45.

Recurrence was noted in Case 25, 8 years later: further operation was refused. It was also noted in Case 60, 2 years later: the patient died.

Case 12 is notable in that embolism of the brachial artery occurred as a sequela, embolectomy being performed.

The plate illustrating this article was taken from a drawing presented to me by J. Howell Evans, M.A., M.D., M.Ch. (Oxon.), F.R.C.S., of London. The specimen, a calcified hydatid cyst of the liver, was removed at operation from a woman aged 56, who made a complete recovery.

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PYELOVENOUS BACKFLOW AT THE TIME OF PYELOGRAPHY

By FRANK HINMAN, M.D., F.A.C.S., San Francisco

THE occurrence of a backflow of the contents of the ureter and pelvis into the venous system has been a constant observation during the last 4 or 5 years in which injection methods of studying the renal circulation have been used. In the collodion-corrosive method of demonstrating the arterial circulation it was a common observation that some of the venous system was demonstrated by an overflow from the pelvis (4).

On account of its frequency a more detailed experimental study was undertaken by the writer and Lee-Brown, of the University of Sydney, Australia, and the results of this study published (5). The term pyelovenous backflow was applied to the phenomenon which was found to be of universal occurrence in all cadaver kidneys studied, including the human kidney, and at back pressures always below the maximal secretory pressure of each respective animal. Subsequent microscopic search failed in each instance to reveal extravasation or local rupture, and in view of these facts the probable importance of the phenomenon to clinical problems was suggested, particularly its relation to the mechanism of hydronephrosis, to hæmorrhage in intermittent hydronephrosis, and to the accidents of pyelography (5). The conclusion was somewhat contradictory to that obtained by others, notably Blum, Tennant, Eisendrath, Mason, and Burns and Swartz (see bibliography in the article by Hinman and Lee-Brown, 5), but since publication has itself received several adverse criticisms.

Fig. 1. (Reproduced through the courtesy of Dr. Leon Herman.) Pyelogram after the injection of 20 cubic centimeters of sodium iodide solution under somewhat increased pressure. It seems to show typical pyelovenous backflow as evidenced by the striations in the cortex and the arching configuration at the cortico-medullary zone and also, because of short brush-like tufts, a certain degree of tubular backflow in the papillary ducts.

In a contribution on "Pyelography in Renal Diagnosis" (3), Herman cites a pyelogram interpreted by him to demonstrate a ready backflow of the pyelographic medium into the uriniferous tubular system. "This condition was produced by the injection of 20 cubic centimeters of the sodium iodide solution under somewhat greater pressure than is used ordinarily in the making of a pyelogram. It will be noted that the pyelogram is peculiar only in the fact of tubular filling; the pelvis is normal in outline." Through the courtesy of Dr. Herman, this pyelogram is reproduced in Figure 1, and we cannot accept his interpretation of the picture but regard it as a typical instance of pyelovenous backflow as would be demonstrated in a living subject with an active renal circulation. The reasons for this difference of interpretation are given below.

More recently, Bird and Moise (1) were stimulated to undertake an experimental study to demonstrate by what path pyelovenous backflow occurs. "The thought occurred to us that by carrying out the experiments of Hinman and Lee-Brown with a

Fig. 2. Photograph of a characteristic multilobed type of renal pelvis and calyces of a human infant 7 months old, injected by the collodion-corrosive method.

Fig. 3. Photograph of arterial and ureteral injection of the kidney of a human infant of 7 years. The distinct arterial distribution is demonstrated by the ease with which the dorsal branch was separated and the lateral view shows the intimate relation of the interlobar arteries passing in the interstices between the minor calyces to the pelvis. Interlobar veins accompany these interlobar arteries.

solution of iron ammonium citrate and potassium ferrocyanide, which produces the Prussian blue reaction when added to an acid-formaldehyde fixing fluid, we might be able to determine quite accurately the path of 'pyelovenous backflow,' if such a flow, indeed, occurred." They were unable to demonstrate any such backflow and concluded: "Our experiments do not support the conception of a true 'pyelovenous backflow' as described by Hinman and Lee-Brown." Since this above publication we have had a number of communications from urologists telling us of pyelograms showing a backflow up the papillary ducts, and it is because of these various contradictions that we would submit the following facts.

It is essential in a problem of this kind to have a clear understanding of the arterial and venous relationships to the pelvis and its ramifications (Fig. 2). The human kidney is a multilobed kidney in contradistinction to that of the majority of experimental animals such as the rabbit, rat, cat, dog, and sheep which are all unilobed type kidney with one papilla. The renal artery ordinarily shows three main branches which pass up into the hilum and ramify through the interstices of the various minor calyces forming interlobar and arcuate arteries from which the finer radial ramifications of interlobular arteries pass at right angles to the renal surface to supply the cortex. There are no nutrient arteries to the medulla nor to the individual papillæ (Fig. 4) and the arterial arrangement is distinctly an end one, there being no anastomosis between any of the branches. The venous backflow from the kidney follows in general that of the arteries, but has distinct differences. The dichotomous end arterial arrangement of the arteries (Fig. 3) is replaced by a very pronounced venous anastomosis (Fig. 5). The interlobar veins pass up next to the wall of the calyces, and in some places are in almost direct contact with the mucosa of the calyces, large venous spaces being seen in close relation to the lumen of the calyces on microscopic section (Figs. 6 and 7). These interlobar veins arch around the pyramids in these calycine fornices, and it

Fig. 4

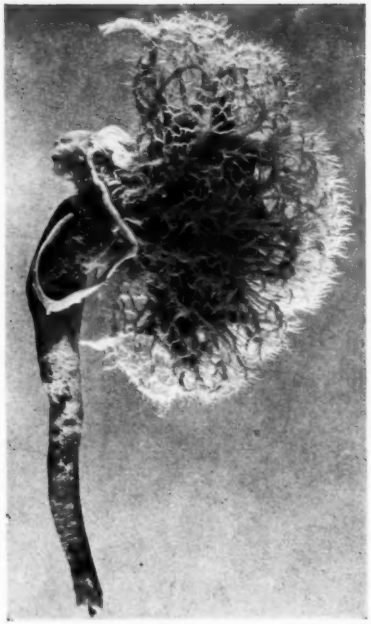

Fig. 5

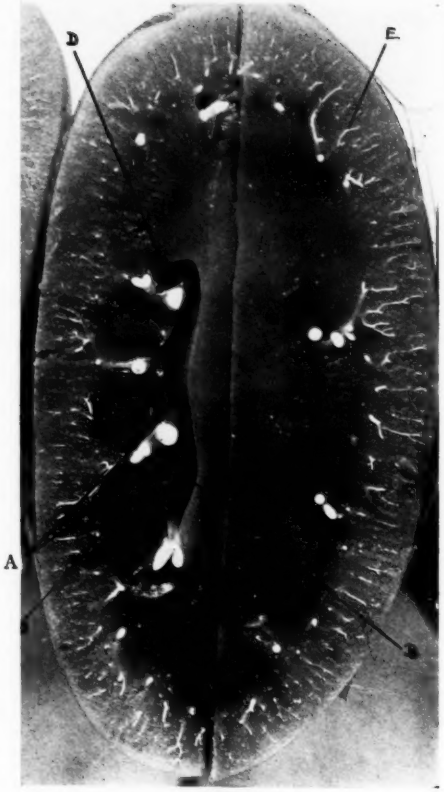

Fig. 6

Fig. 4. Photograph of a collodion-corrosive preparation of arterial and pelvic injection of a human kidney of an infant 6 years old, which shows the general arterial arrangement in relation to pelvis and calyces. It is seen that the arteries are all end arteries.

Fig. 5. Kidney of a human infant of 6 years after ureteral, arterial, and venous injection. An accessory artery to the upper pole has been overlooked at the time of injection, and at this point the venous arcades are more clearly demonstrated. The radial arrangement from these arcades of the interlobular vessels is well shown. It is at this point that the radial striations in pyelovenous backflow appear.

Fig. 6. Coronal section of unilobed sheep's kidney after barium sulphate injection which shows the intimate relation of the large interlobar veins to the calyces. *A*, The arteries injected with the barium sulphate gelatin mixture; *B*, the lumen of the pelvis; *D*, the veins and *E*, the interlobular arteries.

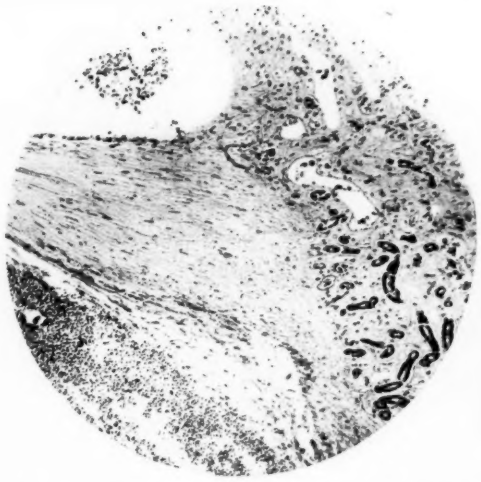

Fig. 7. Photomicrograph of a longitudinal microscopic section of an area similar to that shown in Figure 6, showing the wall of a calyx at the point of reflection on to the renal pyramid. The large venous sinuses at this point are well demonstrated.

would seem to be mainly at this point, particularly in the unilobed kidney, that a pyelovenous communication is first established. The intimate relationship of these large interlobar veins to the gutter-like calyces of the dog's pelvis is well shown in the photograph, Figure 8.

Interlobar veins arch deeper into the kidney substance and form multiple anastomosing arcades, into which the straight interlobular veins from the cortex empty (Figs. 9 and 10). The gross relationship of the tubular system of the kidney to this circulatory arrangement is of considerable importance. The interlobar and arcuate arteries pass between cortex and medulla and the interlobular arteries are found in the cortex only, and the same general relationship applies to the venous system. The veins and arteries pass alongside the pyramids to this cortico-medullary zone, and the relation of the circulation to cortex and medulla is well shown in Figure 11 for the human kidney and in Figure 12 for the unilobed kidney, the venous system of which in this illustration was injected by way of the ureter by reason of pyelovenous backflow.

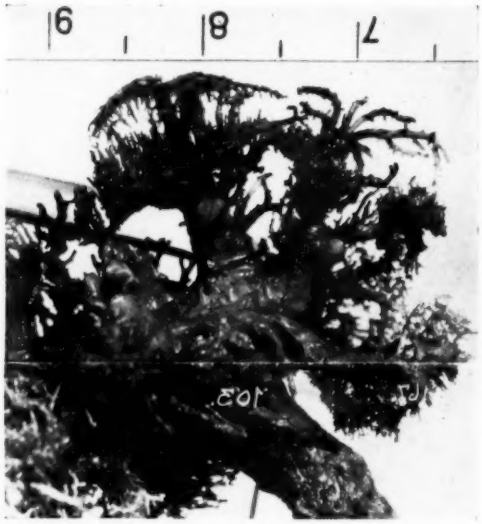

Fig. 8. Photograph of collodion-corrosive preparation of a dog's kidney after ureteral and venous injection. The photograph is taken at a dissected area and shows the intimate relationship of the superficial and deep venous system to each other and to the pelvis. The complete investment of the interlobar vessels by the gutter-like calyces in the unilobed type kidney is well shown.

Fig. 9. Photographic reproduction of an X-ray photograph of a human kidney after barium sulphate venous injection which demonstrates the pronounced venous arcades at the cortico-medullary zone and the radial arrangement of the interlobular vessels in the cortex draining into these. Compare this picture with that obtained on ureteral injection shown in Figure 17.

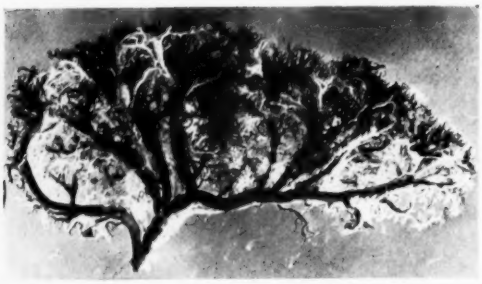

Fig. 10. Photograph of a collodion-corrosive preparation of a human kidney of an infant 6 years old after arterial and venous injection. The two halves have been separated and the picture shows a longitudinal section, viewed from the medial aspect, which shows the intimate relation of arterial and venous interlobar vessels and the pronounced anastomosis of the venous as compared to the distinct end arterial arrangement of the other system.

Fig. 12. Photograph of one-half of a sheep's kidney, the venous system of which has been injected with Berlin blue by way of the ureter, showing an extensive pyelovenous backflow. The radially arranged interlobular veins are particularly well demonstrated and the cortical and medullary zones well differentiated. Interlobar and arcuate veins at the cortico-medullary area are also well shown.

As has been emphasized by Huber (Fig. 13), the tubular system is arranged in such a manner in the relation of its four portions to this circulatory arrangement as to cause the very definite zones as shown in the two illustrations mentioned, the medulla having no glomeruli nor convoluted tubules and the papillæ having papillary ducts and collecting tubules only.

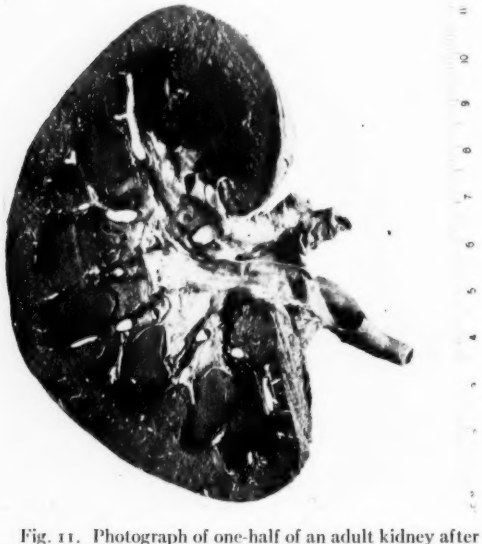

Fig. 11. Photograph of one-half of an adult kidney after barium sulphate arterial injection showing the more intimate relationship between parenchyma and pelvis and the line of demarcation between cortex and medulla. The multiple pyramids are shown with the entrance of interlobar vessels between. The radially arranged interlobular vessels are only partially shown.

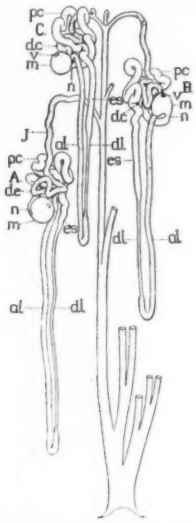

Fig. 13. Diagrammatic representation of 3 uriniferous tubules and their relation to a collecting tubule after Huber. The papillary duct with the radiating collecting tubules from this is well shown. By insertion of a capillary tube into such a duct it is possible to inject, when pressure is applied in a certain way, the tubular system above. Under conditions of pyelography, backflow occurs up the papillary duct for a short distance only and one would not expect filling of the tubular system to give a picture of radiation. The massed nature of these tubules and their minute caliber would most certainly give a blurred picture after their injection and not the distinct arching and radiation as seen with pyelovenous backflow.

Fig. 14. Photograph of a fornix calycis of a human kidney, after ureteral injection with a color gelatin mass, showing the partial filling of the ducts of Bellini. In injections with a fluid menstruum occasionally one of these ducts will appear to be injected to its terminal branching in the cortex, but in no instance have we been able to demonstrate a tubular backflow into the convoluted portions or beyond the collecting duct of one of these ducts of Bellini. Permeation rom these collecting ducts into the rich venous sinuses alongside is possible in some instances.

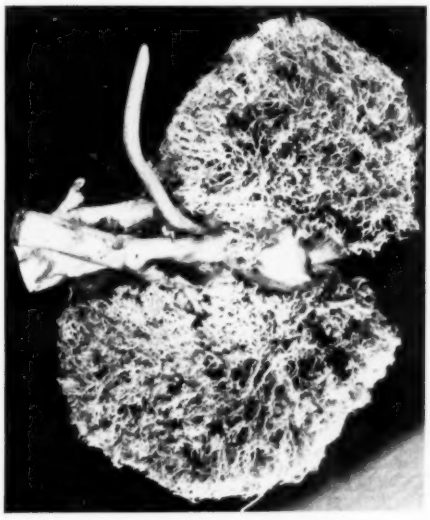

Fig. 15. Photograph of collodion-corrosive preparation which has been dissected to show the short radiating sheaf or brush-like bundle into the papilla from the center of a minor calyx. (See Fig. 16.)

It is, of course, possible by ureteral injection partially to inject the tubular system (Fig. 14), and such injections as this would show in the pyelogram as a short, radiating sheaf or bundle from the center of a minor calyx (Figs. 15 and 16) but not as the cone-shaped funnel with its arching at the cortico-medullary zone and radiation to the cortex corticis as is usually seen and well illustrated in the pyelogram cited by Herman as an instance of tubular backflow. This relationship can be readily demonstrated in the human cadaver kidney by an X-ray picture (Fig. 17) taken after ureteral injection at moderate pressures and gradually increased for a period. Injection of the tubular system by a different technique is possible.

Traut (8), by the use of fine capillary tubes and dissecting microscope, was able to inject the individual papillary ducts under high pressures and to demonstrate the tubular units above, but such injections as these are never obtained by pyelographic methods. We have repeated Traut's injections with collodion-corrosive methods and have been able to isolate entire tubules which have been thus injected (6).

The relation of the vascular and tubular system in the gross human kidney is well illustrated in Figure 18, and it is seen from this figure how the pyelographic figures above of pyelovenous backflow could not be due to papillary backflow. In some of the pyelograms there are short tufts of tubular injection, but these never extend but a short distance beyond the zone of minor calyces, never into the cortex, which is a relatively thin layer over the medulla as shown in Figures 17 and 18. Tubular backflow into the cortex would give a blurred picture, with no striations; because tubules always have such a small lumen and are so completely massed together.

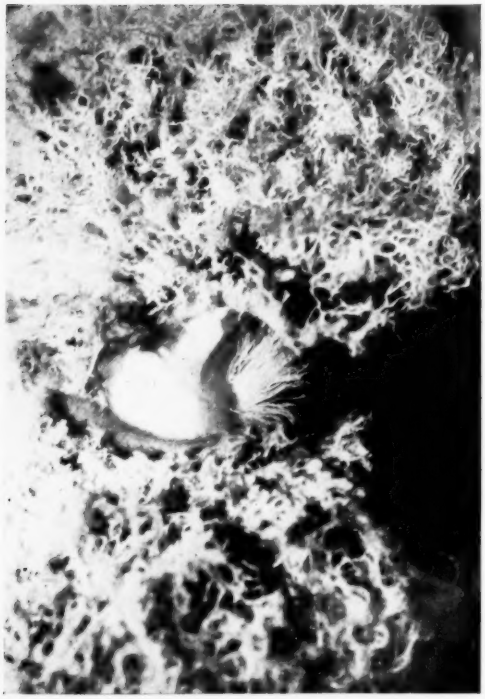

Fig. 16. Photograph of high power magnification of the above point of tubular injection which shows the fine brush-like appearance from the injection of the collecting ducts at the center of a papilla.

The occurrence of a pyelovenous backflow has been independently observed, in 1924 (a year after our publication, 5), by Felix Fuchs of Vienna (2) who shows a typical pyelovenous backflow from ureteral injection in a human kidney.

Wenn ich das Nierenbecken vor dem Roentgenschirm mit 20 proz. Jodkaliloesung injizierte: Bei allmaehlicher Steigerung des Injectionsdruckes wurde das Schattenbild des Kelches durch Abplattung der Papillenspitze zunaechst plumper, hierauf fuellten sich Gefaesse, welche dem Fornix unmittelbar anlagen und sich im weiteren Verlaufe der Injektion durch die Fuellung von arkadenfoermigen Anastomosen als Venen agnoszieren liessen. Erst bei sehr starkem Druck konnte auch das bueschelfoermige Austreten der Kontrastfluessigkeit in das Parenchym (anscheinend in die Ductus papillares) beobachtet werden. Dieser Vorgang laesst sich am besten vor dem Schirm kontinuierlich verfolgen, konnte aber auch auf der Platte festgehalten werden. Abb. 8 zeigt am kaudalen Kelch die Abplattung der

Fig. 17. Photograph of the X-ray picture of a human cadaver kidney with ureteral injection of sodium bromide at 40 millimeter pressure, showing extensive pyelovenous backflow, the venous arcades being demonstrated and the radial arrangement of the interlobular veins shown.

Papille und das erste Austreten des Jodkalis in die angrenzenden Venen. Im Bereiche des kranialen Kelches haben sich dieselben bereits staerker gefuellt, so dass auch die bogenfoermigen Anastomosen zur Darstellung gelangten, ausserdem wurde hier auch das geschilderte bueschelfoermige Austreten der Fluessigkeit in das Parenchym festgehalten. . . . Alle angefuehrten Umstaende sprechen nun dafuer, dass tatsaechlich der Fornix calicis jener Ort ist, an welchem ein Fluessigkeitsuebertritt aus dem Nierenbecken in das Venensystem und umgekehrt den geringsten Widerstand findet, dass mithin diese Stelle auch fuer das Auftreten venoeser Blutungen in das Nierenbecken aus anatomischen Gruenden als Praedilektionsstelle anzusprechen ist.

He was particularly interested in the gross circulatory relationship with respect to renal hæmorrhage and the observation given was made in the course of injecting fifty human cadaver kidneys for purposes of study, but it is in exact agreement with our own observations previously published.

A study of the route taken by pyelovenous backflow, an investigation of which led Bird and Moise to deny its occurrence even, was presented before the Section of Pathology and

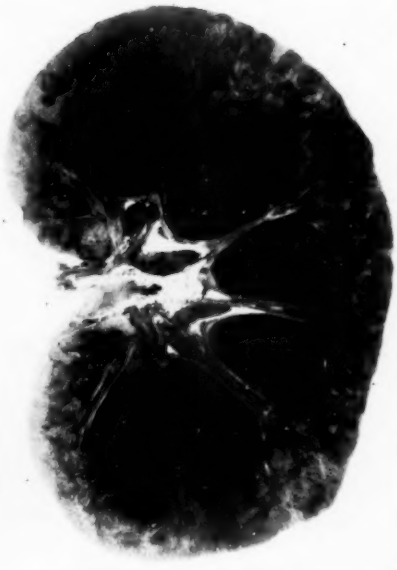

Fig. 18. Photograph of a sagittal section of a kidney which has undergone a peculiar amyloid degeneration, outlining well its tubular system and therefore demonstrating the relation of the blood vascular system to it. The zones of the kidney are well shown, particularly the line of demarcation between cortex and medulla. The straight radiation of papillary ducts from the center of papillæ is also shown.

Fig. 19. Photograph of uretero-pyelogram of a child aged 15 months, in whom a large mass was palpable and the distortion was interpreted as due to renal tumor but is evidently an evidence of partial pyelovenous backflow. The radial arrangement in the cortical area and the arching at the cortico-medullary zone is dimly outlined. The picture illustrates errors of interpretation due to pyelovenous backflow that may occasionally arise.

Physiology of the seventy-seventh session of the American Medical Association, with Dr. Francis Redewill, in which the relative importance of permeability, osmosis, and phagocytosis to venous backflow were considered more in detail (7).

The pyelogram shown in Figure 19 illustrates an instance of pyelovenous backflow clinically and the misinterpretation that may result. In this case, a child aged 15 months, a diagnosis of tumor of the kidney was made on account of the pyelogram and the mass felt on palpation, which proved to be an enlarged liver lobe. The picture shows a possible distortion of the upper portion of the pelvis which, in view of the indefinite X-ray findings in localizing the kidney shadow, led to an exploratory operation. A normal kidney was found, however, its upper pole was incised and nothing abnormal seen. A piece of kidney tissue was excised as near as possible to the point where the filling defect was shown and was found negative microscopically.

CONCLUSION

In conclusion, it may be definitely stated that the pyelovenous backflow frequently occurs at the time of pyelography and that tubular backflow for a short distance into the papillary ducts also occurs. In the case of pyelovenous backflow, radiation into the cortex first appears as a cone or funnel deformity from the base of pyramids, and if back pressure is sufficient may later show the arching

from filled anastomotic venous arches. Radiation into the cortex then appears along the interlobular veins, a picture that never occurs with tubular backflow in which there is a short brush-like radiation from the tip of the papilla into the medulla for a short distance. Such pyelovenous and papillary backflow when unrecognized may lead to errors in interpretation of pyelograms.

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HÆMORRHAGIC CYSTS OF THE KIDNEY[1]

By E. STARR JUDD, M.D., F.A.C.S., Rochester, Minnesota

AND

HAROLD E. SIMON, M.D., Rochester, Minnesota
Fellow in Surgery, The Mayo Foundation

CERTAIN authors do not consider hæmorrhagic cysts of the kidney to be worthy of a separate classification, believing them to be the result of accidental hæmorrhage occurring within simple serous cysts. It has been shown definitely, however, that they possess characteristics which cannot be explained on this basis.

Large solitary cysts of the kidney are of two types, serous and hæmorrhagic. The serous cysts are the more common but the hæmorrhagic create greater interest because of their unusual structure and obscure origin. Cysts containing blood but occurring in association with malignant neoplasms, adenomata or angiomata of the kidney differ from the simple hæmorrhagic cysts, and will not be considered here.

FINDINGS IN THE LITERATURE

Lancereaux and Siredey, in 1858, each described a renal cyst with thick fibrous walls, containing blood. These, however, were found at necropsy and the descriptions of them are rather incomplete.

Souligoux and Gouget reviewed the literature thoroughly up to 1905. They found 7 cases which seemed to them, from both a clinical and surgical standpoint, to be authentic, and reported 1 case which they had themselves observed.

Etcheverry also reviewed the literature to 1905 and summarized the findings in different cases but he included a number in which the diagnosis is open to question.

Poirier, in 1888, reported a case which was apparently overlooked by Souligoux and Gouget. Since 1905 individual cases have been reported by Giuliani and by Begg and 2 cases have been observed at the Mayo Clinic, making a total of 15 cases (Tabulation).

Case 1. A man aged 72 was admitted to the Mayo Clinic February 25, 1924, complaining of a lump in the left upper quadrant of the abdomen. The mass had been present for 1½ years and, although it had not grown much larger during this time, it had become moderately tender. Occasional nocturia and loss of 10 pounds in weight were the only other symptoms.

The patient was fairly well nourished but rather feeble. A movable, slightly tender mass, about 10 centimeters in diameter, was palpable in the region of the left kidney. The systolic blood pressure was 110 and the diastolic 70. The urine contained a trace of albumin and occasionally a small number of red and white blood cells. The blood Wassermann reaction was negative. The hæmoglobin estimation was 77 per cent. Cystoscopic examination revealed a normal bladder. The function of both kidneys was approximately normal. The pyelogram of the left kidney (Fig. 1) showed unusual elongation of the renal pelvis, particularly in the lower calyx. The minor calyces were normal.

A diagnosis was made of either extrarenal tumor or solitary renal cyst and exploration advised. March 3, 1924, the left kidney was exposed through a posterolateral incision. A large cyst of the lower pole, moderately adherent to the surrounding tissues,

Fig. 1. Case 1. Pyelogram of the left kidney which contained a hæmorrhagic cyst. The lower calyx is elongated.

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Fig. 2. Case 1. Kidney with hæmorrhagic cyst occupying the lower pole.

was found. Because of the patient's poor general condition, nephrectomy was not performed at this time but the cyst was opened and on the escape of 600 or 700 cubic centimeters of thin brownish fluid three tube drains were inserted. Three weeks later the patient had improved so that it was possible to remove the kidney together with the cyst. Convalescence was uneventful and the patient was dismissed from observation May 6, the wound having completely healed.

The kidney (Fig. 2) was about normal in size. Small serous cysts were scattered over its surface. In the lower pole was a round yellow and bluish-black cyst approximately 8 centimeters in diameter. The renal capsule was continuous over the cyst and was easily separated from it. The cyst had evidently replaced part of the renal substance but it did not encroach on the pelvis and did not apparently communicate with it. The wall of the cyst varied from 1 to 8 millimeters in thickness and from without inward was composed of renal capsule, a layer of yellowish-white fibrous tissue from 1 to 2 millimeters thick, and an inner layer of variable thickness consisting of several layers of friable blackish brown tissue, apparently old blood clots. Microscopically the wall consisted of the renal capsule with remnants of renal tissue just beneath it, atrophic tubules and glomeruli showing varying degrees of sclerotic changes. There was considerable increase in the interstitial tissue and moderate lymphocytic infiltration. Next to this was a fairly sharply demarcated layer of dense connective tissue which became less dense toward the center. Some muscle fibers and muscle bundles were scattered about and there were small areas of lymphocytic infiltration here and there. A layer of blood of varying thickness formed the inner layer and portions of intima with elastic fibers and an endothelial lining were identified on the inner surface (Fig. 3).

Case 2. A man aged 24 was admitted to the clinic August 17, 1925, complaining of a lump in the right side of the abdomen which he had first noticed 10 days previously.

The patient was well developed and well nourished. A round movable tumor was palpable just beneath the right costal margin. The hæmoglobin estimation was 72 per cent; erythrocytes numbered 4,370,000 and the urinalysis was negative except for a trace of albumin. Roentgenograms of the kidneys, ureters, and bladder were negative. The combined intravenous phenolsulphonephthalein test yielded a return of 70 per cent in 2 hours. Cystoscopic examination revealed a normal bladder and both kidneys were apparently functioning normally. In a pyelogram of the right kidney the pelvis was shown to be displaced laterally, and the calyces markedly rotated, elongated and dilated. Although distorted, the calyces were not destroyed. The pyelogram of the left kidney showed similar deformity but the pelvis and the calyces were nearer the median line (Fig. 4).

A diagnosis was made of a horseshoe kidney with a solitary cyst or a neoplasm on the right side. Operation was advised, and August 25, the right kidney was exposed through a posterolateral incision. A bluish-black, thick-walled cyst about 6 centimeters in diameter was found lying toward the upper pole of the right side of a horseshoe kidney,

Fig. 3. Case 1. Photomicrograph of section through wall of cyst showing three layers, atrophic renal tissue, connective tissue, and old hæmorrhagic areas.

displacing the ureter and the renal vessels laterally. The cyst was opened and about 300 cubic centimeters of thick blood escaped. No communication could be demonstrated between the cyst and the pelvis of the kidney. The wall of the cyst was resected and the oozing, which was considerable, was controlled by clamps and an iodoform gauze pack. The clamps were removed at the end of 72 hours and the gauze was removed on the fourteenth day. Convalescence was uneventful except for a mild bronchitis and drainage of urine from the wound for the first 10 days. The patient was dismissed from observation on the twenty-fourth day with the wound practically healed.

Examination of several pieces of the wall of the cyst showed the outer surface to be smooth, grayish, and covered by a thin capsule which was easily removed and was similar in appearance to a normal renal capsule. The wall was fibrous and varied in thickness from 1 millimeter to 1 centimeter. Here and there within it were brownish-black areas, apparently old hæmorrhagic clots and the inner surface was mottled red and gray from the same cause. Microscopically the structure of the wall was similar to that in Case 1, consisting of three layers. The outer layer was of atrophic renal parenchyma with marked increase of connective tissue and scattered areas of lymphocytic infiltration. Just beneath this was a layer of dense fibrous tissue with many thick-walled vessels and moderate lymphocytic infiltration. The inner layer consisted of old hæmorrhagic

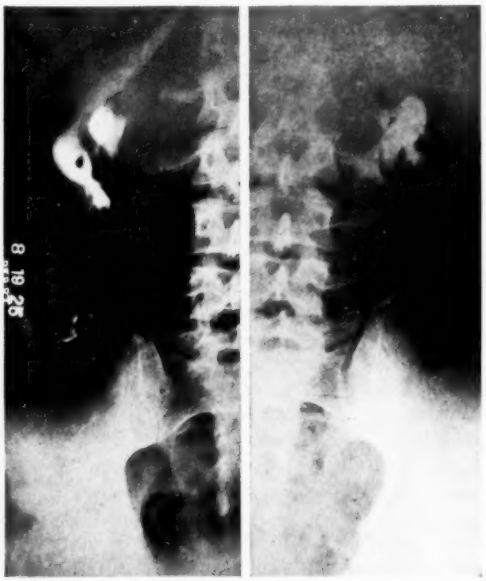

Fig. 4. Case 2. Pyelograms of horseshoe kidney with a hæmorrhagic cyst on the right side.

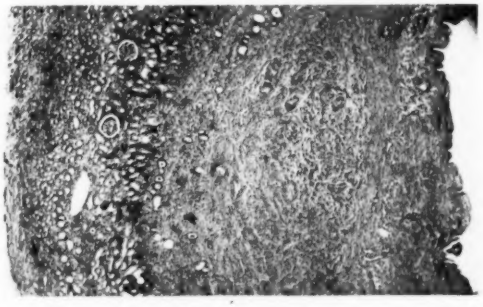

Fig. 5. Case 2. Photomicrograph of section through wall of cyst showing three layers, atrophic renal tissue, connective tissue, and small hæmorrhagic areas. There is one area of smooth muscle bundles and an endothelial layer lining.

areas. In this case also there were bundles of smooth muscle in the fibrous layer and intima with elastic fibers and an endothelial lining could be identified covering portions of the inner surface (Fig. 5). The renal tissue, apart from the cyst, showed only slight arteriosclerotic change.

DISCUSSION OF CASES

Hæmorrhagic cysts of the kidney are practically always solitary and occur in both kidneys with about equal frequency. The site of the cysts is variable although they seem to have a predilection for the inferior pole. The average age incidence in the cases reported was 43½ years, the youngest patient being 16 and the oldest 76. The incidence of sexes was practically equal. Most cysts of this type are large, one reported by Leopold had a capacity of more than 4 liters. A few small ones have been found at necropsy but these would probably pass unrecognized clinically, since they do not cause symptoms.

Externally the cysts are usually smooth and round and continuous with the outer surface of the kidney without any obvious ridge of demarcation. In a few instances they have been nodular. In some cases they are bound down to the adjacent structures by adhesions. Their surfaces are usually opaque and whitish except when hæmorrhage has occurred within the wall producing a mottled blue or black appearance. The renal capsule is continuous over the wall of the cyst and may often be stripped from it. A layer of renal parenchyma showing marked atrophy

and sclerosis forms a fairly constant outer layer while the middle layer is formed of fibrous tissue of varying degrees of density. In both of the Mayo Clinic cases large bundles of muscle were present in the fibrous layer. The inner layer consisted of old hæmorrhagic areas and masses of fibrin. In 3 cases an endothelial lining was noted and in both the Clinic cases remnants of intima were identified.

The cysts contained old partially or completely organized blood clots often arranged in layers around the periphery with more recent clots and masses of fibrin in the central zones. They occasionally contained fresh blood, but usually the fluid was thin and brownish or blackish—brown in which cholesterin crystals, débris, and degenerated blood elements have sometimes been identified microscopically.

There is practically never any communication between the cyst and calyces or the pelvis of the kidney. The single recorded exception is Begg's case in which there was a communication between the cyst and the renal pelvis large enough to admit a bristle. In this case there had been a history of two attacks of hæmaturia each following severe muscular strain. Begg believed that the strain produced so much pressure on the enlarged kidney that the communication with the pelvis was reopened thus permitting the escape of blood into it. The remainder of the kidney is usually normal or at most shows only a moderate degree of arteriosclerotic change.

Even after careful examination, if the wall of the cyst has failed to reveal evidence of neoplasm, several other possibilities remain in the differential diagnosis. Occasionally, as in the case reported by Bradford, there may be continuous bleeding into a hydronephrotic kidney and if the kidney is nearly destroyed there may remain only a thick-walled sac filled with blood which may be difficult to differentiate from a hæmorrhagic cyst. In such case the relation to the pelvis and the ureter is the deciding factor in the diagnosis. Primary hæmorrhage which has become encapsulated resembles such cysts although there is likely to be some calcification, and the superimposed layers of blood-clot are absent.

PATHOGENESIS

The origin of hæmorrhagic cysts of the kidney has not been satisfactorily explained. It has been suggested that they may be hæmatomata which have become encapsulated. In none of the recorded cases, however, has there been any history of trauma which would account for such an accident nor have there been any episodes of acute pain such as would be expected to result from spontaneous hæmorrhage beneath the renal capsule. Bleeding into a serous cyst was suggested by Leopold as an explanation but on this basis we could not account for the striking differences in structure which exist between the walls of the serous and hæmorrhagic cysts. Souligoux and Gouget further objected to this hypothesis on the ground that there is no good explanation for such bleeding, especially in young patients in whom arteriosclerotic processes cannot be considered a factor. They believed, moreover, that continued bleeding or multiple hæmorrhages must be present to produce the superimposed layers of clots of varying age such as are characteristic of these cysts.

Because of the fact that thick-walled blood-containing cysts sometimes occur in association with renal neoplasms some authors have advanced the theory that all hæmorrhagic cysts of the kidney have their origin in neoplasms whose cells may have become destroyed, or which may be so small in comparison to the size of the cyst that they are overlooked in the examination. While this possibility cannot be ruled out definitely, in no instance has metastasis been found either locally or generally, and the benign types of renal tumors which might produce such a cyst, namely the adenomata and angiomata, practically never occur under the age of 30, while 3 instances have been recorded in which hæmorrhagic cysts have occurred in persons younger than 30.

Begg discusses aneurysm as a possible explanation but objects to it on the ground that pulsation has never been noted in any of the cysts. This is not an adequate objection, however, for it is no longer possible to detect pulsation in an aneurysm after the walls have become greatly thickened by clotting. The

structure of the walls could be satisfactorily explained on the assumption that they arise as aneurysms within the renal substance, and as they enlarged, stretched and compressed the overlying parenchyma until only a thin layer of atrophic structures remained. Repeated layers of clotted blood then become deposited on the inner surface of the aneurysm, the outer layers becoming compressed and organized into layers of fibrous tissue more or less intimately attached to the wall. By the time the cavity has become large enough to be recognized clinically the process of clotting has advanced to such a degree that the lumen of the vessel has been partially or completely occluded and the cavity is no longer supplied with fresh blood. The blood already present undergoes autolysis and becomes brownish or black, and the aneurysm, at this stage, ceases to exist because it has been transformed into a cyst. The sudden profuse hæmorrhage reported by Souligoux and Gouget, and by Picqué, which occurred while they were attempting to evacuate the contents of the cyst, probably resulted from the removal of a clot from the lumen of the vessel in which the aneurysm had originated.

The presence of muscle fibers and bundles within the walls of the cyst of both of the Mayo Clinic cases, as well as the finding of remnants of intima, with elastic fibers and an endothelial lining, strongly supports this explanation of their origin.

SYMPTOMS AND DIAGNOSIS

There are no symptoms or signs characteristic of hæmorrhagic cysts of the kidney. By the aid of the pyelogram the tumor can usually be localized in the kidney but there is usually nothing to differentiate it from a serous cyst or a neoplasm. In some instances the cyst is only discovered at necropsy. In the reported cases a tumor was always present, and usually was discovered by the patient. Many of the cysts are globular and smooth; occasionally one is nodular. When small they can sometimes be located in the kidney by physical examination, but they are usually large and localization is impossible. They are often diagnosed as ovarian or pancreatic cysts. Tenderness may be elicited on deep pressure and fluctuation is sometimes noted.

Pain is usually dull and dragging but may be absent or quite severe and simulate renal colic. In some cases there are only rather indefinite gastro-intestinal disturbances resulting from increased intra-abdominal pressure. Usually there are no urinary symptoms and the urinalysis is negative in most instances. In 3 cases only was hæmaturia noted.

The patient's general condition is, as a rule, good. In several cases there was moderate anæmia.

The roentgenological and pyelographic findings do not differ from those in cases of solitary serous cysts.

TREATMENT

The treatment of hæmorrhagic cysts of the kidney is surgical and consists either of resection of the cyst or nephrectomy. Resection is the treatment of choice if it is technically possible and enough of the normal kidney remains to justify the procedure. In order to deliver the cyst it may be necessary first to empty it but in so doing it must be borne in mind that profuse hæmorrhage sometimes follows this procedure and may necessitate packing or immediate nephrectomy. If the cyst is resected, it should be examined immediately for neoplasm and if this is present the kidney should be removed. If the affected kidney is nearly or completely destroyed, or if resection of the cyst is impossible, then nephrectomy should be performed provided the function of the remaining kidney is satisfactory.

COMMENT

Case 1 of the Mayo Clinic series has one feature of unusual interest. It is the only case on record in which any congenital anomaly has been associated with one of these cysts. Such association probably is not significant with regard to etiology but it is significant from the standpoint of surgery, resection of the cyst being necessary under the circumstances. Failing in this, or if there is uncontrollable bleeding, hemi-nephrectomy could be performed.

TABULATION

	Reference	Age, sex	Situation	Symptoms	Treatment	Result	Pathological findings
1	Siredey, 1858	38 M	Right and left kidney	None from cysts	None		One small cyst on each kidney, filled with blood and fibrin. Necropsy specimen; patient died from lead poisoning.
2	Lancereaux, 1858	76 M	Posterior border of left kidney	No renal symptoms except those of prostatic hypertrophy	None		Cyst with thick fibrous wall. Necropsy specimen. Died from "organic stomach trouble."
3	Maisonneuve, 1865	57 M	Convex border of right kidney	Intermittent pain and tumor for 8 months	Punctured, 3 liters brown fluid obtained	Died	Wall of cyst 5 mm. thick, composed of fibrous material. Cholesterin and altered blood identified in contents.
4	Leopold, 1882	33 F	Inferior pole of left kidney	Tumor for 6 years. No renal symptoms	Punctured, 4 liters bloody fluid. Nephrectomy	Recovered	Kidney normal. Wall of cyst 2 to 5 mm. thick. Contained recent and old clots.
5	Lejars and Sebileau, 1887	49 F	Anterior surface of left kidney	Pain in left side for 6 years. Nodular tumor palpable. Urine normal. Anæmic	Exploratory puncture	Died	Large cyst filled with clots and fibrin. Wall consisted of fibrous layers with remnants of renal tubules. Kidney and pelvis normal.
6	Poirier, 1888	48 F	Inferior pole of left kidney	Pain in hypochondrium and flank for 18 months. Urine normal. Tumor palpable	Exploratory puncture	Died	Cyst filled with blood and fibrin. Slight sclerosis of kidney.
7	Bellamy, 1888	44 F	Inferior pole of left kidney	Dragging pain for 3 years. Progressive abdominal enlargement	Punctured. Nephrectomy	Died	Large, thick-walled cyst containing altered blood.
8	Recamier, 1893	59 F	Posterior-superior pole of right kidney	Violent lumbar pain. Kidney enlarged and tender	Resection and cautery	Recovered	Contained 200 gm. serous liquid colored with blood. Kidney normal.
9	Picqué, 1898	35 F	Inferior pole of right kidney	Right lumbar crises for 12 years. Urine purulent; tumor palpable. Tender. General condition poor	Opened and clots removed. Nephrectomy	Recovered	Cyst not connected with pelvis. Considerable hæmorrhage when contents were evacuated.
10	v. Brackel, 1899	18 F	Inferior pole of left kidney	Tumor of recent enlargement. Pain. Urine normal. Condition good for 4 years	Punctured. Excised	Recovered	Fibrous wall with remnants of renal tubules. Kidney normal. No communication with pelvis. Capacity 2.5 liters.
11	Souligoux and Gouget, 1905	16 M	External superior pole of right kidney	Progressively feeble for 5 months. Swelling of right side. Tumor palpable. Fluctuation. Urine normal	Opened and evacuated. Packed	Died	Fibrous wall 1 to 2 mm. thick with remnants of renal tubules. Profuse hæmorrhage when contents were evacuated.
12	Giuliani, 1913	52 F	Inferior pole of right kidney	Hæmaturia and pain following strain. Tumor of right kidney	Nephrectomy	Recovered	Kidney normal. Cyst contained clots and fibrin. No communication with pelvis.
13	Begg, 1926	33 M	Inferior pole of right kidney	Two attacks of hæmaturia in 2 years. Well nourished. Very anæmic	Nephrectomy	Recovered	Diameter 11 cm. Wall 1 to 2.5 mm. thick. Remnants of renal parenchyma identified in wall. Space admitting bristle between cyst and pelvis. Origin in hæmangioma.
14	Mayo Clinic, Case 1	72 M	Inferior pole of left kidney	Tumor for 1½ years. Tender. General condition good	Drainage. Nephrectomy	Recovered	Thick walled cyst contained bloody fluid and clots.
15	Mayo Clinic, Case 2	24 M	Superior pole of right kidney	Tumor palpable for 10 days. Urine normal	Resection	Recovered	Thick walled cyst associated with a horseshoe kidney.

CONCLUSIONS

1. Simple hæmorrhagic cysts of the kidney form a distinct group apart from the serous cysts and the hæmorrhagic cysts occurring in conjunction with neoplasms.

2. The etiology is obscure and none of the hypotheses proposed thus far are entirely satisfactory. The suggestion that the cysts may originally have been aneurysms is the most acceptable one and is the only one that is entirely consistent with the clinical and pathological findings.

3. The cysts rarely occur and their symptoms are not characteristic. The diagnosis has rarely if ever been made pre-operatively, and even at operation it may be difficult to

know that one is not dealing with a neoplasm.

4. Treatment is surgical, consisting in resection of the cyst when feasible, otherwise in nephrectomy.

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END-RESULTS IN FIVE HUNDRED AND SIXTY-THREE CASES OF BREAST CANCER

By BERNARD F. SCHREINER, M.D., F.A.C.S., and A. T. STENSTROM, M.D., Buffalo, New York
State Institute for the Study of Malignant Disease, Buffalo, New York, Burton T. Simpson, M.D., Director

IN the past few years many contributions to the study and treatment of cancer of the breast have appeared. Papers by Dr. Robert Greenough of Boston and Dr. Francis Carter Wood of New York City, and many others, have reported excellent results by the purely operative treatment. These results cover periods of 3 and 5 years. There were included in these papers, so far as we could ascertain, many very early cases of cancer of the breast. The inclusion of these cases would naturally lead the casual observer to believe that surgery is the established treatment for malignant disease of the breast. Yet from the large number of patients applying at this Institute for treatment, many of whom represent cases of postoperative recurrence, it is readily seen that statistics based upon any form of treatment in selected cases would probably give an erroneous idea of end-results.

Between May, 1914, and December, 1925, 5,080 cases of malignant disease were admitted to the hospital of the State Institute; there were 563 cases of cancer of the breast, comprising 11.08 per cent of all cases. In the attempt to make an analysis of the end-results of treatment in these cases, it was very evident that some classification must necessarily be made if we were to convey to others what had been accomplished. We therefore decided on a classification based upon the physical and radiographic examination of the patient at the time of entrance, as follows:

Prophylactic group. In this group were the patients who had been operated upon and showed no evidence of recurrence at admission.

Group I. The patients in this class had a tumor confined to the breast and freely movable on the underlying tissues, the skin as well being movable over the tumor, with no de-

Fig. 1 (left). Case 516. Group III, primary. June 20, 1922. Before treatment.
Fig. 2. Same case as in Figure 1. Photograph taken February 8, 1924, 1 year and 8 months after tumor in breast had been implanted with radium emanation and treated with high power X-ray. Patient is still alive, July 1926, and has had no recurrence.

monstrable metastases in the lymph-bearing areas, axilla or mediastinum.

Group II comprises the cases in which the tumor was confined to the breast with definite involvement of the underlying tissue and skin, or ulceration of the skin with no other demonstrable metastases. This sub-division of Group I was made because we believe that the results of treatment warrant a distinction in the classification.

Group III includes patients with a tumor in the breast and definite metastases in the axilla.

Group IV comprises all cases in which, in addition to the axillary involvement and extensive disease of the breast, definite evidences were present of supraclavicular, mediastinal, or disseminated metastases.

In a classification of this kind one cannot deny that the personal equation enters into the interpretation of the grouping, yet it would seem from our analysis that this was at least justifiable insofar as it gave us a working basis for prognosis and end-results.

TABLE I.—DIVISION INTO GROUPS OF THE 563 CASES

	Number of primary cases	Number cases recurrent or postoperative	Total number cases
Prophylactic	0	66	66
Group I	23	2	25
Group II	55	4	59
Group III	90	41	131
Group IV	88	194	282
Total	256	307	563

The age incidence is depicted in Table II. The youngest patient was 24 years old and the oldest 90 years old; 58 per cent of the cases occurred between the ages of 40 and 60.

Of the 563 patients, 8 were males and 555 females; 479 patients were married and 84 unmarried. The disease was primary in the right breast in 244 cases, in the left breast in 275, and both breasts were involved in 34. A history of cancer in the family was obtained in 133 instances. The Wassermann reaction was positive in 45 patients.

Of the 563 patients, 256 had had no surgical, radium, or X-ray treatment; 307 had been operated upon previous to their admission to the Institute; 269 had been treated by means of the so-called radical operation, either Willy-Meyer, Rodman, or Halstead, and 38 had had incomplete operations.

From our investigation we must deduce that many of these cases of recurrence had been poorly chosen for radical operation, or the procedure in some instances was poorly carried out. On the other hand, many of the operations, so far as one could ascertain, had been done according to the latest and best surgical technique. The history of the average duration of symptoms before entrance was 40 months; 128 patients gave a history of injury, either in the form of a blow, kick, fall or bruise which they thought might have contributed to, or been the cause of their trouble.

TREATMENT

Sixty-three of the patients admitted for radiation had been operated upon. Insofar as one could ascertain from clinical as well as radiographic examination, they were free from the disease at the time of admission and were therefore recorded as cases to be treated prophylactically. Prior to 1920, these patients were treated with low voltage X-rays, 2½ millimeter aluminum filter, in divided doses, 100,000 volts, 5 milliampère, time factors varying from 5 to 15 minutes at 20 centimeters distance. Treatment was repeated sometimes at week intervals or 2-week intervals over a period of 1 to 3 years, with intervals of rest depending on the condition of the skin.

From 1920 to 1925 the patients were treated by means of high voltage X-rays with varying technique as to distance and number of fields applied. During the years 1921, 1922, and 1923, cross-firing and massive doses were tried and resulted in much depression, X-ray sickness; and on the whole did not seem to justify the procedure that was then carried out. Since that time we have modified our technique and the present method is to divide a known quantity of X-rays which is administered over a period of a week to 12 days, allowing for the time elapsed between treatments, the desire

TABLE II.—AGE INCIDENCE

	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	Total
Prophylactic	1	13	19	26	6	1	–	–	66
Group I	–	2	10	8	2	3	–	–	25
Group II	1	2	10	18	14	11	3	–	59
Group III	2	13	32	35	34	11	3	1	131
Group IV	2	19	79	95	56	24	7	–	282
Total	6	49	150	182	112	50	13	1	563

being to administer from 120 to 150 per cent on the skin. The general impression gained is that this procedure is more beneficial as is evidenced by the physical condition; and also, there are fewer recurrences in the time that has passed during the observation of our patients. The same technique has been carried out in the treatment of the patients in Groups I, II, and III, insofar as the roentgen radiation is concerned. The X-rays were at times supplemented with implantation of radium in the primary growth. In selected cases, radical operation has been resorted to, in addition to the radiation. Patients in Group IV have been treated entirely by the divided doses of X-rays already described. In 10 isolated cases operation was used to eradicate foul-smelling, breaking down, ulcerating tumor masses.

DISCUSSION

Of the 66 patients in the prophylactic group, 3 were not treated, 9 were lost trace of, 19 are dead, and 35 are clinically well. Of the 9 that were lost trace of, 4 had remained clinically well from 1 to 2 years and failed to return, 2 did not return after the first treatment, and 3 others had developed recurrences and were lost trace of within 2 years. Of the 19 that died, 10 had local recurrences with general metastases and 9 had no local recurrence, but died from general metastases. The period of palliation varied in length from 6 months to 4 years. The 35 patients have been clinically well as follows: 1 for 11 years, 2 for 10 years, 1 for 7 years, 3 for 6 years, 2 for 5 years, 5 for 4 years, 2 for 3 years, 4 for 2 years, 5 for 1 year, 10 for 6 months to 1 year. Undoubtedly among these 66 patients, the lesion in some of them must have been far advanced at the time of operation. However, we had no knowledge of the extent of the disease at that time.

There were 23 cases in Group I (primary) of which 6 were not treated, 8 were treated with radiation, and 9 with radiation and operation. Of the 8 patients treated with radiation, 3 died, 2 from the disease and 1 from apoplexy. The remaining 5 are alive; 2 have been clinically well for from 4 to 5 years, and 1 has been well for 1 year, the fourth was well for over a year and lost trace of, and the fifth has developed nodes in the axilla but has had palliation for a year. Of the 9 patients treated with radiation combined with surgery, 7 are clinically well and 2 are dead. One died from carcinomatosis 4½ months after admission but had no local recurrence. The other died from local and mediastinal involvement 4 years after admission. Of the 7 patients that are clinically well, 2 have been well for from 5 to 6 years, 2 from 4 to 5 years, 1 over a year, and 2 from 6 months to a year.

In Group I (recurrent, postoperative) there were 2 cases in which radiation treatment was given. One patient has been clinically well for a year and the other for 7 years.

There were 55 cases in Group II (primary) of which 9 were not treated, 32 were treated with radiation, and 14 with radiation and operation. Of the 32 patients treated with radiation, 13 died 1 to 5 years after admission, 4 were lost trace of 1 to 2 years afterward and 15 are alive. Of the 15 living patients, 4 are clinically well, 1 for 2 years, 1 for 3 years, 1 for 4 years, and 1 for 6 years. The remaining 11 patients have had palliation for from 1 to 5 years. Of the 14 patients treated with radiation and surgery, 2 were lost trace of in less than a year, and 4 died 3 to 5 years later; 8

patients are alive, of which 5 are clinically well, 2 for 1 year, 1 for 2 years, 1 for 3 years, and 1 for 6 years. The remaining 3 have had palliation from 2 to 5 years.

There were 4 cases (recurrent, postoperative) in Group II treated with radiation. One did not return after the first treatment and the 3 others are dead; 2 of these patients were clinically well for 1 year and developed recurrences and died 2 and 4 years later respectively.

There were 90 cases in Group III (primary) of which 4 were not treated, 51 were treated with radiation, and 35 with radiation and surgery. Of the 51 treated with radiation, 27 died in less than a year to 3 years later from the disease; 6 were lost trace of in less than a year to 3 years later, 18 are alive, of which 7 have been clinically well, 1 for 1 year, 3 for 2 years, 2 for 3 years, and 1 for 4 years. The remaining 11 patients have had palliation from 1 to 5 years. Of the 35 patients treated with radiation and surgery, 3 were lost trace of in less than a year and 19 died within 1 to 5 years; 1 died from uræmia, having been clinically well for over a year. Of the remaining 18 patients, 15 died from local and general involvement, and 3 had no local recurrence, but died from general metastases; 13 patients are alive, of whom 7 have been clinically well, 2 for 1 year, 1 for 2 years, 3 for 3 years and 1 for 4 years. The remaining 6 patients have had palliation for periods of from less than a year to 5 years.

There were 41 cases in Group III (recurrent, postoperative); 7 patients were not treated, 2 did not return after the first treatment, 21 died in less than a year to 3 years after admission, and 11 are still alive. Of these, 6 have been clinically well from 1 to 2 years and the remaining 5 have had palliation for from less than a year to 3 years.

There were 88 cases in Group IV (primary); 80 were treated with radiation, and 8 with radiation and surgery. Of the 80 patients, 9 were lost trace of within a year after admission, 50 died within 2 years after admission, while 4 lived from 3 to 5 years and then succumbed to the disease. Seventeen patients are alive for from 1 to 4 years; 3 have been clinically well, but their chest plates are suggestive of mediastinal involvement. Of the 8 patients treated with radiation and surgery, 1 was lost trace of within a year, 5 died within 2 years and 2 are alive and having palliation, 1 for 2 years and the other for 4 years.

There were 194 cases in Group IV (recurrent, postoperative), of whom 23 were not treated, 168 were treated with radiation, and 3 with radiation and surgery. Of the 168 patients who were treated with radiation, 21 were lost trace of within a year, 105 died within 2 years, while 14 survived from 2 to 5 years after admission; 28 patients are alive, having had palliation for a period of from less than a year to 4 years. The 3 patients treated with radiation and surgery have been alive and improved from 1 to 3 years.

SUMMARY

1. In 43 per cent of our cases recurrence followed complete or incomplete operation for cancer of the breast.

2. In the prophylactic group, 19 patients died from the cancer, and 35 remained free from the disease from 6 months to 11 years.

3. Of the 8 cases in Group I (primary), treated by radiation alone, 3 patients are clinically well, 2 for 5 years, and 1 for over a year. Of the 9 cases in Group I (primary), treated with radiation plus radical operation, 7 have been clinically well for from 1 to 6 years.

The 2 patients in Group I (recurrent, postoperative), treated by radiation, are clinically well, 1 for 1 year, and the other for 7 years.

4. Of the 32 cases in Group II (primary) treated with radiation, 4 have been clinically well for from 2 to 6 years. Of the 14 patients treated with radiation and surgery, 5 have been clinically well for a period of from 1 to 6 years. We have no cases in Group II (recurrent, postoperative), that are clinically well, although 2 of the 4 treated were well for a year and then developed recurrence and died 1 to 3 years later.

5. Of the 51 patients in Group III (primary), treated with radiation, 7 have been clinically well for a period of from 1 to 4 years. Of the 35 patients treated with radiation and surgery, 7 have been clinically well for from 1 to 4 years. Of the 41 cases in Group III (recurrent,

postoperative), treated with radiation, 6 have been clinically well 1 to 2 years.

6. Of the 80 patients in Group IV (primary), treated with radiation, 17 have been alive from 1 to 4 years after admission, of whom 3 have been clinically well but their chest plates suggest mediastinal involvement. Of the 8 patients treated with radiation and surgery, 2 are alive and have had palliation, 1 for 2 years and 1 for 4 years. Of the 168 cases in Group IV (recurrent, postoperative), treated with radiation, 28 patients are alive, having had palliation from less than a year to 4 years. The 3 cases in Group IV (recurrent, post-operative), treated with radiation and surgery, have been alive and improved from 1 to 3 years.

CONCLUSIONS

The majority of patients presenting themselves at the Institute with cancer of the breast were either cases in which the condition had recurred after operation, or far advanced primary cases.

Our statistics show definitely that results in operable cases are best obtained by radical operation followed by radiation, although in some instances, radiation alone has proved of curative value.

In the recurring cases in Groups I, II, and III, there have been, in isolated instances, cures which have lasted up to 6 years. In the hopeless, inoperable cases of breast cancer, radium and roentgen-ray treatment has made the remaining days of the patient more comfortable.

We realize that no absolute conclusions as to the results of treatment can be drawn from our series of cases because percentages could not be estimated from such a small number of case records.

AN EXPERIMENTAL STUDY OF THE OPERATION OF CHOLECYSTENTEROSTOMY

By MILTON TRAUTMANN, M.D., HOLDEN J. ROBBINS, M.D., AND COLIN C. STEWART, M.D.,
PHILADELPHIA
From the Department of Research Surgery, University of Pennsylvania

THE operation of cholecystenterostomy was first suggested by Nussbaum and first done by Van Winiwarter in 1880. The first one-stage operation of its kind in man was done in 1887 by Monastyrski. Later it was done by other surgeons and came into considerable popularity. Murphy used his button in making the anastomosis. It gradually fell into disfavor as other procedures replaced it and bad results from its too promiscuous and ill-advised use accumulated. Almost every portion of the intestine has been utilized. Early in its history a rather common type was the anastomosis between the gall bladder and colon termed cholecystcolostomy. This operation fell into disuse because it was so frequently associated with severe biliary, hepatic, and peritoneal infection. Today, when it is done, the anastomosis is usually between the duodenum or stomach and the gall bladder, at which sites these complications are not so frequent or severe.

The principle of these operations is to provide internal drainage of the gall bladder, as J. B. Deaver has aptly termed it. The operation has been used to secure drainage in chronic infections of the biliary system, especially of the ducts and gall bladder, or in obstruction to the free flow of bile resulting from causes external to the biliary system, as from obstruction of the common duct by carcinoma of the head of the pancreas. W. W. Babcock (2) has suggested its use for the cure of gastric ulcer on the principle that the bile coats the ulcerous area and thereby assists healing. An undesirable feature, however, is that when the common and cystic ducts are open the stoma of such an anastomosis tends to contract and close. Various methods have been used in an attempt to correct this. Mur-

phy introduced his button for this purpose. We were recently informed of a clinically successful case operated upon by Dr. George Muller of this University, in which a mushroom catheter was left extending through the anastomosis from the gall bladder into the duodenum.

We commenced an experimental study of the operation of cholecystduodenostomy on dogs to determine whether it would be possible to make a permanently patent anastomosis. We took several dogs and did this operation, our technique being that of a lateral anastomosis. All our suture material was of double and triple strand silk. The dogs recovered well from the operation, their appetites returned, and they were objectively quite normal. The first dog was autopsied 9 weeks after operation and the stoma was of good size. The second was autopsied 12 weeks after operation and the stoma was of good size. The third was autopsied 13 weeks after operation and the stoma was large; the gall bladder contained duodenal contents. A cholecystgastrostomy was done on a dog. At autopsy 50 weeks later the stoma was found almost entirely contracted, but admitting a small probe. In 6 other animals autopsied from 3 to 13 weeks after cholecystgastrostomies and cholecystduodenostomies had been done the stomata were all found to be of good size.

We were very much surprised to find the openings patent for such periods of time. However, after the gall bladder of the third dog was found to contain duodenal contents, another plan was added to the original experiment, namely, to find if, after these operations, intestinal contents regurgitated into the gall bladder, and how far.

We now did a series of cholecystgastrostomies and cholecystduodenostomies on dogs, allowing them to recover, and after a time feeding them charcoal impregnated meals. Autopsies were done upon them several hours later and the specimens examined. Two of the animals were also given a barium meal and the progress of the meal watched by fluoroscope and X-ray. Of these 2 dogs, 1 was examined in this manner in the fiftieth week after the operation of cholecystgastrostomy. Neither the fluoroscope nor the plate showed barium in the biliary system. It was this dog which at autopsy showed an almost completely obliterated stoma. Later, this same dog was autopsied 3½ hours after eating a charcoal meal; and the specimen when examined showed no black particles in the gall bladder or ducts. The gall bladder did, however, contain a few strands of hair. These, we believe, entered while the stoma was still large, and remained there. Many of our specimens showed hair mixed with the intestinal contents.

In the case of the second dog the X-ray and fluoroscopic report states that there was distinct filling of the gall bladder which emptied a greater part of the barium in the first 6 hours but probably did not empty completely until almost the twelfth hour. A trace of the meal was apparently still retained in one of the ducts at the end of 24 hours. The interval between operation and autopsy here was 10 weeks, the operation having been a cholecystgastrostomy. Autopsy 3 hours after a charcoal meal showed the stoma of good size and black particles extending into the gall bladder and cystic duct, with a small bundle of hair in one of the hepatic ducts.

In this connection we would refer to an article by Habbe and Smith (7) in which a case was presented of unusual bile duct visualization. In the course of a gastrointestinal X-ray it was found that when the patient lay on his back the duodenal peristalsis gradually filled the gall bladder, cystic, and hepatic ducts through what, from the history of the case, must have been a spontaneously produced cholecystduodenostomy. After 48 hours there still were traces of the meal in the hepatic ramifications. A few other cases of visualization of the bile ducts are referred to in this paper, notably that of Stephenson (10), Carman (4), and Beall and Jagoda (3). In these cases it would seem that peristaltic contractions of the intestine had much to do with the appearance of the meal in the biliary system. In the case by Habbe and Smith this was observed under the fluoroscope.

In an article by Heyd (8) we find the statement that postoperatively X-rays show no bismuth or barium in the gall bladder

when a cholecystgastrostomy has been done. W. W. Babcock (2) also stated that he had observed practically the same thing. However, we think that this subject needs some revision. At least in dogs this occurs with regularity until the stoma becomes much contracted. For the most part, the evidence in man is fragmentary.

Upon autopsy following the feeding of charcoal meals we found that in every case but one intestinal contents entered the gall bladder, but only once did we find them beyond the cystic duct. In the dog the cystic duct contains no valves of Heister, hence it ought to be easier for particles to traverse it.

Intestinal peristalsis, we think, causes intestinal contents to appear in these gall bladders. Archibald (1) showed that cholecystenterostomy in the dog in the presence of a patent common duct, as in our animals, does not divert the flow of bile from the common duct to any appreciable extent. Therefore, in our dogs the factor of resistance from drainage of bile against the ingress of intestinal contents could be ignored. If Archibald is correct, one wonders how this operation relieves symptoms,—perhaps by providing drainage for infected material or by diverting the bile when there is complete obstruction of the common duct.

In the search for evidences of inflammation, all sections were prepared from the gall bladder near the entrance of the cystic duct, and from the middle portion of the common duct. Infection, we thought, might occur from intestinal contents. None of the livers showed gross evidence of infection.

Gatewood and Poppens (5), from cultures of biliary contents before and after operations of this kind on dogs, concluded that the gall bladder becomes infected in every case, regardless of the portion of intestine with which the anastomosis is made, and that there is little difference in the rapidity of the onset of such infection, but that the anastomosis with the duodenum or stomach is safest, a view which has been borne out clinically.

Babcock (2) states that neither he nor his associates have seen clinically a case of secondary infection of the biliary system in 130 cholecystenterostomies seen in 4 years. One wonders, therefore, whether if such infection occurs it may be safely ignored.

Lehman (9) tried to devise an operation to prevent liver infection by interrupting all lymphatic connections with the field of operation. He, too, found that in every case the gall bladder contained hair and stomach contents, that none of the livers appeared normal although they varied in their appearance, and that in all the groups there were microscopic evidences of inflammation in the liver, moderate in a majority and severe in a few.

Biliary contents are usually sterile, even with cholelithiasis. The sphincter of Oddi and the flow of bile prevent ascending infection. With these operations the sphincter's action against infection is nullified by the new opening, and if Archibald is correct we need not consider the drainage of bile important enough to prevent infection. The normal stomach is sterile, the duodenum only relatively so. Grey (6) has shown that cholecystgastrostomy, at least when his animals were on a diet of meat and water, had no appreciable effect upon gastric acidity even though alkaline bile was being poured into the stomach. Yet Gatewood and Poppens (5) found that dogs developed biliary infections with this operation almost as rapidly as with anastomoses to other parts of the intestinal tract. Heyd (8) has found gastric acidity also unaffected in these operations.

In examining our sections we found that in one animal, autopsied a week after operation, both gall bladder and common duct were subacutely inflamed. In another in which the interval was 50 weeks the gall bladder was normal and the duct showed low grade inflammation. In 3 others with intervals of 10, 9, and 4 weeks both gall bladder and ducts showed evidence of chronic inflammation. In another with an interval of 13 weeks the gall bladder was normal, the duct subacutely inflamed. In another with an interval of 9½ weeks the gall bladder was chronically inflamed, the duct normal. In the last 2 with intervals of 10 and 12 weeks there were no evidences of inflammation.

To sum the matter up, of 18 sections, 11 showed inflammatory changes and 7 showed

SUMMARY OF RESULTS IN TEN CHOLECYSTENTEROSTOMIES

Dog	Operation	Intervals in weeks between autopsy and operation	Condition of stoma	Hours between charcoal meal and autopsy	Distribution at autopsy of meal in biliary system
1	Cholecyst-gastrostomy	50	Very small and almost wholly closed	3.5	Some hair in gall bladder but no black particles.
2	Cholecyst-gastrostomy	10	Patent and large	3.5	Black particles seen in stomach, gall bladder, cystic duct. Small mass of hair in a hepatic duct.
3	Cholecyst-duodenostomy	9	Patent and large	Not done	
4	Cholecyst-duodenostomy	12	Patent and of good size	Not done	
5	Cholecyst-duodenostomy	13	Patent and of good size	No charcoal given	Duodenal contents found in gall bladder.
6	Cholecyst-duodenostomy	3	Patent and of good size	3.5	Black particles in gall bladder, cystic duct and duodenum.
7	Cholecyst-gastrostomy	1	Patent and large	Not done	
8	Cholecyst-duodenostomy	9.5	Patent and of good size	3.5	Mercurochrome was used to tint the food here but it was made too dilute, and could not be detected in the gall bladder. No evidence of intestinal contents in gall bladder.
9	Cholecyst-duodenostomy	12	Patent and large	3.5	Particles in duodenum, gall bladder and cystic duct.
10	Cholecyst-gastrostomy	10	Patent and large	3	Particles found in stomach, gall bladder and cystic duct.

none. Of 9 sections of gall bladder, 5 showed evidence of inflammation and 4 did not. Of 9 sections of common duct, 6 showed inflammatory changes and 3 did not. In this connection we would point out that the conclusions that can be drawn from this can only be grossly correct since we examined only one small section from the gall bladder and one from the common duct.

In these experiments inflammatory changes followed the operation in 61 per cent; in 55 per cent the gall bladder showed evidence of inflammation, and the common duct in 66 per cent. This is a rather even distribution of inflammatory change when we consider that gross duodenal contents were only once found beyond the cystic duct. We believe that these infections were carried in by the intestinal contents and we feel certain that in no case did the animal suffer from these inflammations. It is, however, interesting to note that infection of the biliary system can occur through its lumen from infected contents. In our series, it is to be pointed out that 50 per cent of the specimens examined were from cholecystgastrostomies and the other 50 per cent from cholecystduodenostomies, showing that the site of operation had apparently no effect in preventing inflammation. Where Gatewood and Poppens found 100 per cent of infection in the gall bladder following these operations, we have found 61 per cent. Infection of the common duct occurs as frequently as, and usually coincidently with infection of the gall bladder.

SUMMARY

In 10 cholecystenterostomies, the fistula produced remained open for at least 15 weeks and in 1 case for 50 weeks.

In every case in which the opening was patent, food passed into the gall bladder and

several times into the cystic duct. Food was found only once beyond the cystic duct, and then in one of the hepatic ducts.

In a cholecystgastrostomy, with an opening of good size, the X-ray and fluoroscope demonstrated barium in the gall bladder and ducts, a trace remaining in the ducts still after 24 hours. In another, with an almost wholly obliterated opening, barium did not pass into the biliary system.

No gross evidence of liver infection was seen at autopsy.

Following these operations the gall bladder and common duct became inflamed in 61 per cent of the cases, the duct perhaps 10 per cent oftener than the gall bladder. The inflammation was of a low grade in the majority of cases.

CONCLUSIONS

1. In every case of cholecystenterostomy in the dog, intestinal contents pass into the common and cystic ducts, rarely beyond, as long as the opening is of good size.

2. Intestinal contents, after cholecystenterostomy, set up, usually, a low grade inflammation of the gall bladder and common duct; that is, after an anastomosis with the stomach or duodenum. We think that the character of this inflammation is such that in certain cases of grave obstruction for which this operation is being considered, one need not hesitate unduly in choosing it for fear of subsequent inflammation.

We wish to acknowledge here our debt to Dr. J. E. Sweet for his close supervision of this work and to Dr. A. E. Colcher, of Philadelphia, for his assistance with the X-ray.

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THE EFFECTS OF THYROIDECTOMY AND THYROID FEEDING ON THE CARDIAC OUTPUT

STUDY NUMBER FOUR ON THE REGULATION OF CIRCULATION

BY ALFRED BLALOCK, M.D., AND TINSLEY RANDOLPH HARRISON, M.D., NASHVILLE, TENNESSEE
From the Departments of Surgery and Medicine of Vanderbilt University

IN a previous communication (11) observations have been reported which indicate that there is an increased cardiac output in dogs with pneumonia. The change in cardiac output was demonstrated to be closely related to changes in the oxygen saturation and oxygen carrying power of the blood and to be somewhat less related to changes in oxygen consumption. These findings led us to believe that the oxygen supply was an important factor in the control of the cardiac output. With such a condition as pneumonia, definite conclusions could not be reached without studying separately so ne of the various factors pi esent in animals with this disease.

Pneumonia is accompanied by elevation of body temperature, which, as is well known, is a manifestation of increased tissue oxidation. In the study of the relation of the oxygen supply to the regulation of the circulation it seemed best to investigate first the effects of changes in the metabolic rate on the cardiac output.

Since the metabolic rate can be controlled by the thyroid gland the effects of increased and decreased thyroid function have been studied. Other workers have made similar observations. Eppinger, von Papp, and Schwarz (8), using the plethysmograph, noted an increased blood flow through the arm in hyperthyroidism. In 2 of the 4 patients which they studied, the coefficient of utilization of oxygen in the arm was decreased, indicating that the blood flow was probably increased. The other 2 patients had normal coefficients of oxygen utilization, suggesting a normal blood flow. Davies, Meakins, and Sands (5) determined the cardiac output in patients with hyperthyroidism before and after operation, and found a fairly close correlation between the oxygen consumption and the cardiac output. Robinson and Burwell studied one patient with hyperthyroidism and found the cardiac output increased relatively more than the oxygen consumption. Odaira (16) found that rabbits fed with thyroid gland showed an increase of 44 to 144 per cent in the oxygen consumption and an increase of 241 to 270 per cent in the cardiac output. In a series of rabbits after thyroidectomy Odaira found diminution in oxygen consumption of 10 to 52 per cent and diminution in cardiac output of 20 to 59 per cent.

All observers agree that the increased oxygen consumption due to excessive thyroid secretion is associated with an increased cardiac output. There is no general agreement as to the quantitative relationship in changes of metabolic rate and cardiac output. In the experiments reported below interest has been particularly directed to this point, to the effect on the cardiac output of the administration of iodine, and to the "recovery" of the heart from thyroid intoxication.

METHOD

Male dogs were used in all experiments. Most of the animals received morphine .004 and .008 grams per kilo 60 to 90 minutes before the beginning of the experiment. We used two trained unanæsthetized dogs in order to be certain that the results obtained were not influenced by morphine.

The animal was put in the dorsal position on a table and samples of arterial and venous blood were drawn from the two ventricles. The usual precautions against contamination with air were taken. The oxygen content of the arterial and venous blood was determined by the Van Slyke-Neill (22) manometric apparatus, duplicate analyses being made. The oxygen consumption was determined by means of a Benedict spirometer with the Roth (18) graphic recording device. Duplicate records of 5 to 10 minute observation periods were made. In the earlier experiments

a paraffined plaster of Paris mask was used—in the later experiments this was replaced by a specially constructed rubber mask. For further details as to technique the reader is referred to previous papers (1, 11, 13).

The cardiac output was calculated from the Fick formula:

$$\frac{\text{Cubic centimeters oxygen consumed per minute.}}{\text{Amount of oxygen taken up by 1 cubic centimeter of blood in passing through the lungs.}} = \text{No. of cubic centimeters of blood passing through the lungs per minute.}$$

In one series of experiments the thyroid gland was removed after two or more control determinations of the cardiac output had been made. In several instances the extirpation of the thyroid was complete. In these an effort was made to avoid the parathyroids, but this was not always successful as two animals died of tetany. In other instances subtotal thyroidectomy was done. None of these animals developed tetany. Several died of distemper complicated by pneumonia. After thyroidectomy the cardiac output was determined at intervals of 2 to 7 days until the animals died or the experiment was terminated.

In a second series of dogs, thyroid substance[1] was given by mouth. The initial dose was 0.13 gram and the amount was gradually increased to 0.67 gram daily. After a period of 4 to 8 weeks of thyroid feeding the animal was given Lugol's solution 0.5 cubic centimeter by mouth daily, the thyroid feeding being continued. After 10 to 14 days both iodine and thyroid substance were discontinued. During the period of thyroid feeding the cardiac output was determined once or twice a week. For approximately 3 months after the feeding of thyroid substance had been discontinued determinations were made every 7 to 14 days.

The details of the individual experiments are recorded in protocols at the end of the tables.

RESULTS

A. The effects of thyroidectomy. Nine animals were studied but 6 of these died before the series of observations were completed. The results in the remaining animals are given in Tables I, II and III.

The general condition of the animals was observed. In the experiments in which the extirpation of the gland was complete, the animal became immediately listless and refused to eat. In 2 or 3 days activity returned and the dog appeared normal. Within 7 days weakness was again noted. The animal refused food and would not walk. The body weight rapidly decreased. The pulse rate increased. No change in body temperature was found. The hair began to fall out. Death occurred in 3 weeks—apparently from inanition.

The general condition after partial or subtotal thyroidectomy was quite different. For the first 2 or 3 days after operation the animal was very much excited, walked about the cage continually and barked frequently. The appetite, pulse rate, and oxygen consumption were increased and the body temperature was slightly elevated. After a few days of excitement one animal (Table II) gradually developed weakness and listlessness, lost weight and died in 2 weeks. Another animal (Table III) continued to show excitement and hunger for 3 months after the operation. A second operation was done and the remaining thyroid tissue removed. Sections demonstrated an epithelial hyperplasia with enlargement of the cells.

The microscopic picture was similar to that seen in exophthalmic goiter. Following the second operation this animal developed the usual picture of cachexia thyreopriva and died in 2 weeks. During the period between the first and second operations the observations indicated hyperthyroidism rather than hypothyroidism.

The oxygen content of both the arterial and venous blood was decreased in all experiments in which the thyroid gland was wholly or in part removed. The diminution in arterial oxygen content was progressive. The hæmoglobin, as estimated by the arterial oxygen content, decreased to 60 to 70 per cent of that present before operation. Anæmia is therefore present in experimental as well as clinical hypothyroidism.

[1] Thyroid gland—desiccated, Eli Lilly and Co.

TABLE I.—THE EFFECTS OF THYROIDECTOMY ON THE OXYGEN CONSUMPTION AND CARDIAC OUTPUT

Dog V8

Date	Morphine grams	Weight kgms.	Temperature Fahrenheit	Pulse rate per min.	Arterial oxygen vols. per cent.	Venous oxygen vols. per cent.	Arteriovenous difference vols. per cent.	O_2 Consumption c.cm. per min.	Cardiac output c.cm. per min.	Per cent. change in cardiac output	Per cent. change in O_2 consumption	Output per kgm. per min. c.cm.	Output per beat c.cm.
11-3-25	.06	16.4	100	72	16.2	10.6	5.6	124.3	2219	Control	Control	136	31
11-4	.06	16.4	99.6	70	16.2	10.56	5.66	125.8	2222	Control	Control	136	31
11-5										Thyroid	ectomy		
11-6	.06	15.4	97	86	13.16	5.25	7.91	118.4	1498	−33	− 6	96	17
11-8	.06	15.1	99.2	98	12.8	6.95	5.85	113	1932	−13	−10	128	20
11-10	.06	14.6		93	13.4	7.7	5.7	106.7	1871	−16	−15	128	20
11-16	.06	12.8	96	90	12.14	6.71	5.43	79.6	1466	−34	−37	114	16
11-19	.06	12.3	99.8	60	12.21	6.90	5.31	86.4	1627	−27	−31	132	27
11-22	.06	13.0	97.6	78	10.67	5.54	5.13	77.3	1507	−32	−38	116	19
11-26	.06	12.4		78	11.38	7.15	4.23	68.4	1617	−27	−45	130	21

Protocol: 11-3-25, healthy male dog, control determination. 11-4, control determination. 11-5, thyroidectomy. 11-6, animal very weak. 11-8 to 11-18, mild distemper. 11-28, found dead. Autopsy, heart and lungs appeared normal. Microscopic sections showed normal lungs.

TABLE II.—THE EFFECTS OF THYROIDECTOMY ON THE OXYGEN CONSUMPTION AND CARDIAC OUTPUT

Dog V14

Date	Morphine grams	Weight kgms.	Temperature Fahrenheit	Pulse rate per min.	Arterial oxygen vols. per cent.	Venous oxygen vols. per cent.	Arteriovenous difference vols. per cent.	O_2 Consumption c.cm. per min.	Cardiac output c.cm. per min.	Per cent. change in cardiac output	Per cent. change in O_2 consumption	Output per kgm. per min. c.cm.	Output per beat c.cm.
12-8-25	.04	9.3	100.3	70	19.21	13.86	5.35	74.0	1383	Control	Control	149	0
12-9	.04	9.3	100	80	18.18	13.30	4.88	69.9	1432	Control	Control	154	18
12-9										Thyroid	ectomy		
12-11	.07	9.3	102.1	174	16.13	11.24	4.89	124.9	2554	+81	+73	274	15
12-13	.06	8.6	100.2	60	16.77	9.93	6.84	62.2	909	−35	−14	106	15
12-15	.03		102	112	16.89	8.53	8.36	74.6	892	−37	+ 4		8
12-18	.03	7.7	100.2	112	14.52	8.19	6.33	62.7	990	−30	−13	128	9
12-21	.03	7.6	101	90	13.62	7.63	5.99	70.0	1166	−17	− 3	153	13

Protocol: 12-8 and 12-9, control determinations, subtotal thyroidectomy after last determination. 12-11, appetite voracious, very restless. Rapid breathing. Mucous membranes flushed (apparently having thyrotoxic reaction). More morphine than usual required to make animal quiet. 12-13, eating poorly, listless. 12-15, animal weak. 12-29, found dead. Autopsy, heart and lungs normal. Microscopic study of lung tissue showed it to be normal.

The venous oxygen content decreased to a greater degree than did the arterial oxygen content, and the coefficient of utilization was consequently increased.

The oxygen consumption decreased steadily after total thyroidectomy (Table I). When the removal of the gland was incomplete, a rise in oxygen consumption occurred immediately after the operation (Tables II and III) and a marked subsequent fall did not occur. In one animal the oxygen consumption remained practically normal for 3 months after the first operation, but rapidly fell following removal of the remaining thyroid tissue.

The cardiac output decreased in all the animals except the one which showed no significant change in oxygen consumption; the degree of anæmia was greater in this animal than in the others. Other experiments have shown that anæmia increases the cardiac output and oxygen consumption. This animal at the time of the second operation was found to have hyperplasia of the thyroid gland. It

TABLE III.—THE EFFECTS OF THYROIDECTOMY ON THE OXYGEN CONSUMPTION AND CARDIAC OUTPUT

Dog V20

Date	Morphine grams	Weight kgms.	Temperature Fahrenheit	Pulse rate per min.	Arterial oxygen vols. per cent.	Venous oxygen vols. per cent.	Arteriovenous difference vols. per cent.	O_2 Consumption c.cm. per min.	Cardiac output c.cm. per min.	Per cent. change in cardiac output	Per cent. change in O_2 consumption	Output per kgm. per min. c.cm.	Output per beat c.cm.
1–15–26	.04	6.6	98	50	17.92	10.2	7.72	69.9	905	Control	Control	137	18
1–18	.04	6.6	101	66	16.01	9.18	6.83	69.4	1016	Control	Control	154	15
1–19										Thyroid	ectomy		
1–20	.04	6.7			14.24	9.41	4.83	65.3	1352	+ 41	− 6	199	
1–23	.04	6.9	101.4	112	15.30	10.13	5.17	69.8	1350	+ 41	0	196	12
1–26	None	6.8	100	60	13.18	9.34	3.84	55.2	1437	+ 50	−20	211	24
1–30	.04	7.0	99.4	48	11.11	7.26	3.85	52.7	1369	+ 43	−24	195	28
2–3	.04	7.0	100.2	60	11.31	4.38	6.93	54.9	792	− 17	−21	115	13
2–13	.04	7.7	101	84	7.40	2.58	4.82	59.0	1223	+ 27	−15	159	15
2–18	.06	8.2	98	60	8.79	6.49	2.30	50.6	2200	+129	−27	268	37
2–27	.06	8.9	100	64	10.32	7.41	2.91	67.3	2312	+141	− 4	260	36
3–25	.06	8.9	100	60	14.60	10.67	3.93	65.5	1666	+ 74	− 6	187	28
4–15	.04	8.9	100.4	64	14.89	11.02	3.87	62.2	1607	+ 67	−10	181	25
4–22					Remain	ing thyroi	d tissue re	moved					
4–28	.03	7.5	99	53	13.80	2.83	10.97	47.3	431	− 55	−32	57	8

Protocol: 1–15 and 1–18, control studies. 1–19, thyroidectomy, intracapsular enucleation, small amount of tissue left at both upper poles. During next 3 weeks animal appeared well but developed a marked anæmia. Slow recovery from anæmia. 4–22, remaining thyroid tissue removed. Sections showed marked hyperplasia. 5–1, found dead. Heart and lungs appeared normal.

is probable that these complicating factors explain this dog's atypical reaction. After the complete removal of the thyroid gland the cardiac output decreased.

In general the change in cardiac output was proportionately greater than was the change in oxygen consumption. This was also noted in rabbits by Odaira(16). The significance of this disproportion, which would probably have been greater had not the dogs developed anæmia, will be discussed later. The cardiac output per beat was diminished.

B. The effects of feeding thyroid. Sixty-three determinations of cardiac output were made on 3 animals. The general condition of these dogs corresponded in most respects to that of patients with hyperthyroidism. The pulse rate and appetite increased; the animals became very active. The animals gained in weight while receiving thyroid. Body temperatures were slightly higher during the period of thyroid feeding.

The oxygen content of the arterial blood varied considerably from time to time, but no constant change was found. The venous oxygen content also showed inconstant variations. On the whole the coefficient of utilization, that is, the difference between the oxygen content of arterial and venous blood, was somewhat less during the period of thyroid feeding than during the control periods.

The oxygen consumption (Fig. 1) was increased, as would be expected. In one animal (Table VI) an initial drop in oxygen consumption occurred, for which there is no explanation. The maximum increase in oxygen consumption was 118 per cent. The usual increase after 0.7 gram of thyroid had been given for 4 to 6 weeks was +60 per cent to +80 per cent. Marked variations were encountered in the same animal on different days, but in general the degree of increase in oxygen consumption corresponded with the duration of thyroid feeding.

The cardiac output (Fig. 1) was increased. The rate of increase in cardiac output at first was found to be less than that of the oxygen consumption. Later the cardiac output increased rapidly and showed greater relative elevation than the metabolic rate. The

TABLE IV.—THE EFFECTS OF DESICCATED THYROID TISSUE AND IODINE ON THE OXYGEN CONSUMPTION AND CARDIAC OUTPUT

Dog V16

Date	Morphine grams	Weight kgms.	Temperature Fahrenheit	Pulse rate per min.	Arterial oxygen vols. per cent.	Venous oxygen vols. per cent.	Arteriovenous difference vols. per cent.	O_2 Consumption c.cm. per min.	Cardiac output c.cm. per min.	Per cent. change in O_2 consumption	Per cent. change in cardiac output	Output per kgm. per min. c.cm.	Output per beat c.cm.
12–22–25	.06	12	101	62	17.25	11.52	5.73	81.2	1418	Control	Control	118	23
12–23	.06	12	99	60	17.38	11.61	5.77	85.3	1478	Control	Control	123	25
	12–28 to	1–4–26, g	iven desi	ccated th	yroid glan	d, .13 gra	m daily						
12–31	.04	11.8	102.4	66	16.18	10.32	5.86	85.6	1461	+ 3	+ 1	124	22
	1–5 to 1–	7, given	3 gram t	hyroidda	ily. 1–7	to 1–11, gi	ven .4 gra	m thyroid	daily				
1–5–26	.04	11.6	102.3	64	13.95	7.90	6.05	100.8	1666	+ 21	+ 15	143	26
1–11	.04	10.2	101	120	15.14	8.85	6.29	113.5	1804	+ 37	+ 25	177	15
	1–12 to 1	–15, ani	malrefus	ed food c	ontaining	thyroid.							
1–12	.06	10.2	102	76	15.02	8.51	6.51	110.4	1693	+ 33	+ 17	166	22
	1–16 to 1	–23, give	n .4 gram	thyroid	daily								
1–22	.06	10.4	99.1	66	14.66	9.18	5.48	108.3	1976	+ 30	+ 37	190	30
	1–24 to 2	–17, rece	ived .7 gr	am thyro	id daily.								
1–28		10.7	103.1	132	13.87	8.87	5.0	118.4	2368	+ 43	+ 64	221	18
2–2		12.0	103.2	156	14.97	7.83	7.14	181.0	2535	+118	+ 75	211	16
2–4		12.0	102.4	128	14.21	9.45	4.76	148.5	3120	+ 79	+115	260	24
2–12		13.0	104.0	128	15.46	10.25	5.21	175.3	3365	+111	+132	260	26
2–16		13.9	103.2	152	15.47	10.16	5.31	178.2	3356	+115	+132	241	22
	2–17 to 3	–2, recei	ved .4 gr	am thyr	oid and .5	c.cm. Lug	ol's soluti	on daily					
2–19		14.5	103.0	152	15.21	10.01	5.20	171.0	3288	+106	+127	227	22
2–22		15.0	103.0	120	14.28	7.41	6.87	138.3	2013	+ 67	+ 39	134	17
2–27		15.2	101.5	135	16.90	10.54	6.36	141.3	2221	+ 70	+ 53	146	16
3–2		15.7	103.2	156	16.93	10.22	6.71	177.6	2647	+114	+ 83	169	17
	3–3, thyr	oid and L	ugol's so	lution di	scontinue	d							
3–10		15.5	102.3	140	16.17	10.62	5.55	160.1	2885	+ 93	+ 99	186	21
3–18		17.0	103.3	144	17.15	12.95	4.20	144.0	3428	+ 74	+137	202	24
3–26		16.3	103.2	112	13.40	9.39	4.01	135.6	3381	+ 63	+134	206	30
4–1		17.0	103.0	140	17.88	12.73	5.15	126.2	2450	+ 52	+ 69	144	18
4–10		16.6	101.0	106	17.43	12.49	4.94	111.5	2257	+ 34	+ 56	136	21
4–19		16.3	102.1	82	16.41	11.32	5.09	130.6	2566	+ 57	+ 77	158	31
4–25		16.3	100.8	116	16.68	11.73	4.95	123.5	2494	+ 49	+ 72	153	21
5–10		16.0	103.0	92	14.76	9.42	5.34	116.5	2181	+ 40	+ 56	136	24

Protocol: 12–22–25, healthy male dog. Control determinations on 12–22 and 12–23. 12–28–25 to 1–4–26, given desiccated thyroid gland, .13 gram daily. 1–5 to 1–7, given .3 gram thyroid daily. 1–7 to 1–11, given .4 gram thyroid daily. 1–12 to 1–15, animal refused food containing thyroid gland. 1–16 to 1–23, given .4 gram thyroid daily. 1–24 to 2–17, given .7 gram thyroid daily. 2–17 to 3–2, given .4 gram thyroid and .5 c.cm. Lugol's solution daily. 3–3, thyroid and Lugol's solution discontinued.

greatest increase in cardiac output was +139 per cent and the usual increase after 4 to 6 weeks was 80 to 120 per cent. These facts indicate that thyroid substance has a specific effect on the myocardium and that this effect occurs later than the effect on metabolism, but once established is of greater degree and lasts longer.

C. The effects of the administration of iodine. After the animals had been in the stage of marked hyperthyroidism for several weeks, iodine was given as Lugol's solution, 0.5 cubic centimeters per day by mouth, thyroid feeding being continued. The effects on the pulse rate, oxygen consumption, and cardiac output of 3 dogs are given in Table VII.

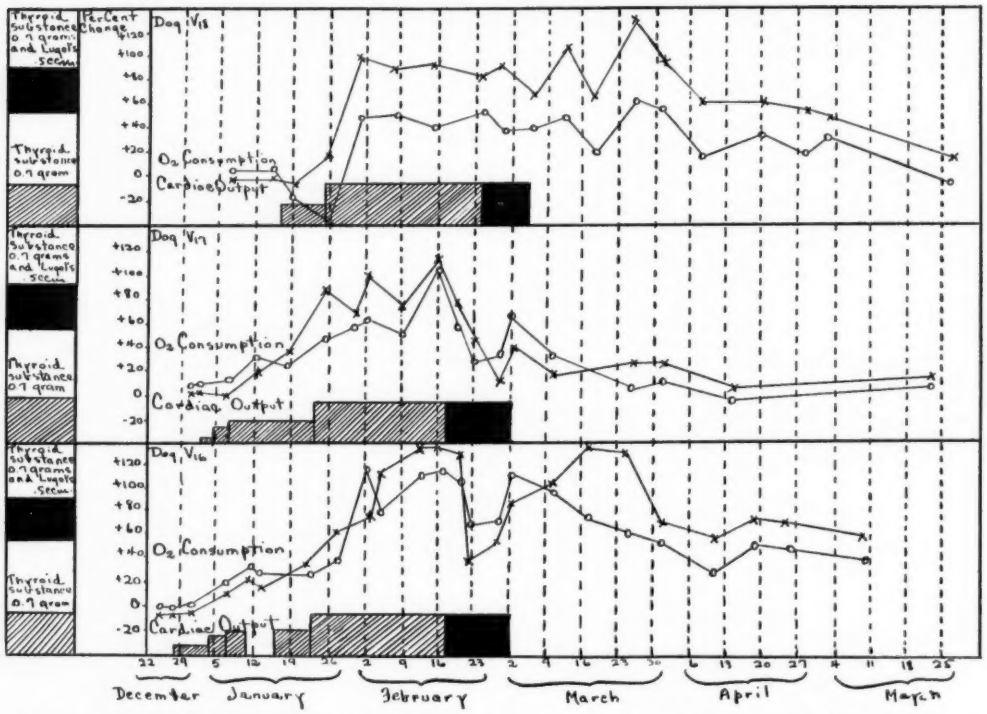

Chart I. Showing the percentage change in (1) cardiac output and (2) oxygen consumption caused by thyroid tissue and Lugol's solution. The symbol "X" denotes cardiac output per minute while "O" denotes oxygen consumption per minute. It is seen that the former function increases to greater degree and remains elevated for a longer time. In 2 of the 3 animals, iodine produced a striking decrease in cardiac output and oxygen consumption. The changes in the third animal were similar in direction but not as marked. The iodine effect is shown to last only a short time and is followed by an increase in the oxygen consumption and cardiac output.

From this table it can be seen that the administration of iodine reduced the pulse rate, oxygen consumption, and cardiac output. The maximum iodine effect was obtained approximately at the end of the first week. The effect was less if the drug was continued for a longer period. The clinical significance of this finding will be discussed later.

D. Recovery from experimental hyperthyroidism. The animals were studied for 3 months after thyroid feeding was discontinued. They remained in good health. During the first month the oxygen consumption and cardiac output remained at almost the highest level observed during the period in which thyroid substance was being given. During the second month the oxygen consumption decreased, but the cardiac output showed relatively less decline. After approximately 3 months the oxygen consumption was +40 per cent, +16 per cent and +2 per cent of the control figures, whereas the cardiac output was +56, +23, and +19. These findings indicate an effect of thyroid substance which lasts for a considerable period after the administration of the drug has been stopped. This may be due to a storing of the drug in the tissues or stimulation of the thyroid gland. The results further indicate that thyroid substance, which is well known to have a direct anatomical effect on the heart, also has a more or less specific functional effect on the heart, since this organ is stimulated to greater degree

TABLE V.—THE EFFECTS OF DESICCATED THYROID TISSUE AND IODINE ON THE OXYGEN CONSUMPTION AND CARDIAC OUTPUT

Dog V17

Date	Morphine grams	Weight kgms.	Temperature Fahrenheit	Pulse rate per min.	Arterial oxygen vols. per cent.	Venous oxygen vols. per cent.	Arteriovenous difference vols. per cent.	O_2 Consumption c.cm. per min.	Cardiac output c.cm. per min.	Per cent. change in O_2 consumption	Per cent. change in cardiac output	Output per kgm. per min. c.cm.	Output per beat c.cm.
12–30–25	.04	12	96	48	16.41	11.34	5.07	87.4	1724	Control	Control	144	36
12–31	.04	11.8	99.1	48	16.92	10.48	6.44	88.3	1371	Control	Control	116	29
	1–2–26to	1–4, giv	en thyroi	d, .13 gra	m daily.	1–5 and 1	–6, given	thyroid .3	gram dai	y			
1–6–26	.07	11.4	100	48	15.36	8.86	6.50	99.4	1529	+ 13	− 1	134	32
	1–7 to 1–	23, given	thyroid	.4 grams	daily.								
1–12	.06	10.9	99.2	48	16.32	10.05	6.27	115.9	1848	+ 32	+ 19	170	38
1–18	.04	10.9	101.4	64	14.1	9.07	5.03	106.8	2123	+ 22	+ 37	195	33
	1–24 to 2	–17, give	n thyroid	.7 gram	daily								
1–25	.06	12.3	99.4	120	15.64	11.16	4.48	131.3	2931	+ 50	+ 89	238	25
1–29	.07	12.3	101.2	80	14.74	9.17	5.57	139.9	2512	+ 60	+ 62	205	31
2–2	.06	13.0	98.0	90	17.03	12.35	4.68	145.5	3108	+ 66	+101	239	35
2–9	.06	13.9	100.0	102	16.04	11.07	4.97	131	2636	+ 50	+ 70	190	26
2–16	.03	15.2	101.0	112	15.5	9.90	5.60	187.4	3346	+114	+116	220	30
	2–17 to 3	–2, thyro	id .7 gra	m contin	ued, Lugo	l's solutio	n .5 cc. da	ily begun.					
2–19	.06	15.5	100.0	60	13.98	8.69	5.29	140.6	2658	+ 60	+ 72	171	44
2–23	.06	16.0	99.0	63	14.78	9.17	5.61	115.9	2066	+ 32	+ 34	129	33
2–27	.04	15.6	99.2	55	16.02	9.12	6.90	120.2	1742	+ 37	+ 13	112	32
3–2	.06	15.5	99.0	72	16.54	10.04	6.50	146.1	2248	+ 67	+ 45	145	21
	3–2, Lugo	l's soluti	on and th	yroid dis	continued								
3–10	.06	14.5	98.0	68	15.23	8.81	6.40	120.1	1871	+ 37	+ 21	129	27
3–26	.06	15.5	97.3	52	14.43	9.87	4.56	93.6	2053	+ 7	+ 33	132	40
4–1	.06	15.5	100.0	66	14.86	9.90	4.96	100.1	2018	+ 14	+ 31	130	31
4–14	.06	15.7	99.8	56	14.17	8.49	5.68	94.8	1669	+ 8	+ 8	106	30
5–23	.06	14.1	101.2	60	14.10	8.76	5.34	101.5	1901	+ 16	+ 23	135	32

Protocol: 12–30–25 and 12–31, control studies on normal dog. 1–2–26 to 1–4, given thyroid tissue, .13 gram daily. 1–5 and 1–6, given thyroid tissue, .3 gram daily. 1–7 to 1–23, given thyroid tissue, .4 gram daily. 1–24 to 2–17, given thyroid tissue, .7 gram daily. 2–17 to 3–2, given thyroid tissue, .7 gram daily and Lugol's solution .5 c.cm. daily. 3–2, Lugol's solution and thyroid discontinued.

and for a longer time than are the body tissues in general.

DISCUSSION

Although the physiological and clinical aspects of this work cannot be sharply differentiated they are considered separately for the sake of convenience.

The regulation of circulation is of major importance and is possibly as important as the regulation of breathing which due to the observations of Zuntz (23), Haldane and Priestly (10), Van Slyke (21), Cullen (4), and others, is better understood. Harrison, Wilson, and Blalock (13) have demonstrated that the hydrogen ion concentration is an important factor in the control of the cardiac output of morphinized dogs, and these authors agree with Boothby (2), Douglas and Haldane (6), and Means (15) that the acid-base balance probably plays a similar rôle in man.

In view of the significance of the hydrogen ion concentration and hence of carbon dioxide in the regulation of circulation it seemed that oxygen might possibly be of similar importance. Since it is a function of the circulation to supply oxygen and to remove carbon dioxide, it was to be expected that the amount of blood pumped would vary more or less in proportion to the gaseous interchange. As

TABLE VI.—THE EFFECTS OF DESICCATED THYROID TISSUE AND IODINE ON THE OXYGEN CONSUMPTION AND CARDIAC OUTPUT

Dog V18

Date	Morphine grams	Weight kgms.	Temperature Fahrenheit	Pulse rate per min.	Arterial oxygen vols. per cent.	Venous oxygen vols. per cent.	Arteriovenous difference vols. per cent.	O_2 Consumption c.cm. per min.	Cardiac output c.cm. per min.	Per cent. change in cardiac output	Per cent. change in O_2 consumption	Output per kgm. per min. c.cm.	Output per beat c.cm.
1-7-26	.04	9.1	98	52	16.17	10.67	5.50	81.3	1478	Control	Control	162	28
1-14	.04	8.4	99.3	64	16.92	8.10	7.92	97.2	1227	Control	Control	146	19
	1-16 to 1	-25, give	n desicca	ted thyro	id gland .4	gram dail	y						
1-19	.06	8.0	99.1	54	13.39	7.32	6.07	76.4	1259	− 7	−14	157	23
1-26	.06	8.2	98.1	108	13.12	8.80	4.32	69.9	1618	+ 20	−22	196	15
	1-26 to 3	5, given	desiccat	ed thyroi	d gland .7	gram dail	y						
2-1		8.9	103	96	14.30	9.42	4.88	132.8	2721	+101	+49	305	29
2-8		9.4	104	120	15.61	10.48	5.13	131.0	2653	+ 89	−48	272	21
2-15		10.2	102	102	15.01	10.01	5.00	125.1	2502	+ 85	+41	245	24
2-24		11.4	103	136	15.44	9.87	5.57	136.8	2438	+ 80	+53	214	18
	2-25 to 3	5, given	desiccat	ed thyroi	d gland .7	gram and	Lugol's s	olution .5	c.cm. dail	y			
3-1		11.6	103	119	15.68	11.10	4.58	121.7	2657	+ 97	+37	229	22
3-5		11.9	103	120	16.29	10.81	5.48	126.3	2305	+ 71	+42	193	19
	3-5, thyr	oid and L	ugol's so	lutiondis	continued								
3-12		12.7	103	112	15.99	11.43	4.56	130.2	2855	+112	+46	224	26
3-17		12.0	103.2	180	15.24	10.72	4.52	107.6	2358	+ 75	+21	196	13
3-26		11.1	102.4	98	17.16	12.72	4.44	143.1	3223	+139	+61	290	33
4-1		11.4	102	108	16.53	11.49	5.04	138.3	2744	+103	+55	241	26
4-10		11.3	102	68	17.73	13.42	4.31	102.4	2376	+ 76	+15	210	35
4-20		11.4	101.4	82	17.07	11.50	5.57	130.6	2345	+ 74	+47	206	29
4-29		10.2	103	108	16.34	11.26	5.08	112.2	2209	+ 64	+26	217	20
5-2		10.2	100.2	92	15.18	9.00	6.18	126.0	2039	+ 51	+42	200	22
5-27		10.5	100.3	76	14.73	9.30	5.43	87.3	1608	+ 19	− 2	153	21

Protocol: 1-7-26 and 1-14-26, control studies. 1-16-26 to 1-25-26, given desiccated thyroid gland .4 gram daily. 1-26-26 to 3-5-26, given desiccated thyroid gland .7 gram daily. 2-25-26 to 3-5-26, given desiccated thyroid gland daily .7 gram and Lugol's solution .5 c.cm. daily. 3-5-26, thyroid and Lugol's solution discontinued.

TABLE VII.—THE EFFECTS OF DESICCATED THYROID TISSUE AND IODINE ON THE PULSE RATE, OXYGEN CONSUMPTION, AND CARDIAC OUTPUT

	Dog V16			Dog V17			Dog V18		
	Pulse rate per min.	Oxygen consumption, c.cm. per min.	Cardiac output c.cm. per min.	Pulse rate per min.	Oxygen consumption, c.cm. per min.	Cardiac output c.cm. per min.	Pulse rate per min.	Oxygen consumption, c.cm. per min.	Cardiac output c.cm. per min.
Before receiving iodine	152	178.2	3356	112	187.4	3346	136	136.8	2438
After iodine for 1 to 3 days	152	171.0	3288	60	140.6	2658	119	121.7	2657
After iodine for 6 to 8 days	120	138.3	2013	63	115.9	2066	120	126.3	2305
After iodine for 9 to 13 days	156	177.6	2647	72	146.1	2248			
After 7 to 9 days without iodine or thyroid	140	160.1	2885	68	120.1	1871	112	130.2	2855

mentioned above other observers have demonstrated such variations and our results agree with those previously published.

It is important to determine how this adjustment is brought about. A complete answer is not available at the present time,

but this work, as well as observations on acidosis and some unpublished findings in anæmia and anoxæmia, suggest that the circulation is so regulated as to keep the pO_2, pCO_2, and pH of the tissues as nearly constant as possible. Stated in a different way the factors controlling circulation seem to be the same as those controlling respiration—namely oxygen pressure, carbon dioxide pressure, and hydrogen ion concentration. These factors may be of different degrees of importance in the control of the two functions.

Thyroid disease is recognized as a factor in the production of cardiac disorders. Hyperthyroidism is an important cause of circulatory disturbances. Levine and Sturgis (14) have pointed out that the symptoms of the circulatory disturbances may mask the underlying cause more or less completely. Fahr (9) has recently directed attention to the frequency of heart disease in the presence of myxœdema, which he believes can be relieved in large measure by thyroid medication. Christian (3) has pointed out the danger of administration of thyroid substance in cases with severe cardiac symptoms, basing his objections on the view that the administration of thyroid may be expected to increase the work of the heart. Considerable uncertainty has existed in regard to the value of digitalis in the "thyroid heart."

In view of these gaps in our knowledge the study of cardiac output in animals with experimental disturbances of thyroid function may be of some clinical value and certain suggestions based on this study are offered. It is of course possible that the heart of the dog and the heart of man are not entirely comparable.

The cardiac output was decreased in the dogs with hypothyroidism, and this is probably also true in patients with myxœdema. If such individuals be treated with thyroid substance an increase in cardiac output may be expected. Hypertension and myxœdema are occasionally associated and one should hesitate to stimulate the heart when it is working against an increased load.

We agree with Christian that there is danger in the administration of thyroid extract in patients with myxœdema and symptoms of circulatory insufficiency. The value of digitalis in certain types of chronic cardiac insufficiency cannot be questioned. Harrison and Leonard (12) have recently shown that digitalis decreased the cardiac output in normal dogs. To administer one drug to increase cardiac output and another to decrease it can scarcely be deemed rational therapy, and we believe that digitalis should be given and thyroid withheld in such cases—at least during the stage of active or impending decompensation.

Anæmia, which increases the cardiac output, is often present in myxœdema and may be of severe degree, as Emery (7) has shown.

When thyroid substance was fed, the metabolic rate increased before the cardiac output changed. However, after prolonged administration of the drug the cardiac output was increased proportionately more than was the oxygen consumption and did not decrease as rapidly after thyroid medication had been stopped. These findings suggest that thyroid has a direct effect on the heart, in addition to the general effect on the body tissues. It is well known that the anatomical changes are encountered in the heart muscle of patients dying of hyperthyroidism. These considerations offer additional evidence for the urgency of early radical treatment of hyperthyroidism. Of the several forms of organic cardiac disease, that which complicates hyperthyroidism is the only one in which, with our present methods, a cure is possible.

Since Plummer and Boothby (17) demonstrated the value of iodine in hyperthyroidism, many favorable reports have appeared. Hopes were entertained at first that iodine might render operation unnecessary in many cases, but the present opinion, as expressed by Sturgis and Greene (20) and Starr, Walcott, Seagall and Means (19), is that this drug is chiefly of value as a pre-operative and postoperative measure.

In these experiments, iodine, administered daily as Lugol's solution 0.5 cubic centimeter caused a marked decrease in oxygen consumption and in cardiac output. The maximum effect was obtained after approximately one week, and further administration appeared to be ineffective. From the standpoint of the heart as well as from the standpoint of the

metabolic rate, iodine may therefore be said to be of great value as temporarily alleviating hyperthyroidism.

There is no general agreement as to the value of digitalis in hyperthyroidism. Harrison and Leonard (12) found that digitalis in full therapeutic doses decreases the output of the normal dog's heart by approximately 20 per cent. The following figures were obtained on two dogs with hyperthyroidism.

Animal	Cardiac output before digitalis c.cm. per min.	Cardiac output after digitalis c.cm. per min.	Percentage change in cardiac output	Metabolic rate: percentage variation from normal
Dog V16	3120	2710	−14	+83
Dog V18	2502	2210	−12	+51

From these observations we may conclude that digitalis effects the heart in hyperthyroidism in the same manner as it effects the normal heart—though possibly to a somewhat lesser degree. Digitalis should be given to patients with hyperthyroidism whether cardiac insufficiency is present or not.

In dogs the cardiac output did not return to normal for 60 to 90 days after the cessation of thyroid medication. There is doubt as to whether this fact is to be attributed to storage of thyroid substance in the body or to stimulation of the thyroid gland.

SUMMARY

The effects of thyroidectomy and of the administration of thyroid substance on the cardiac output of dogs have been studied. The following results have been obtained:

1. The cardiac output is increased in hyperthyroidism and decreased in hypothyroidism. The change in cardiac output is usually somewhat greater than the change in metabolic rate.

2. The administration of iodine to animals receiving thyroid substance is followed by a marked decrease in cardiac output as well as in metabolic rate. This decrease continues for 6 to 10 days, after which the cardiac output and metabolic rate increase rapidly.

3. The metabolic rate and cardiac output remain elevated for 2 months or longer after the cessation of thyroid feeding. The former returns to normal before the latter.

4. Digitalis decreases the output of the heart of dogs with hyperthyroidism, but this effect is somewhat less than the effect on the cardiac output of normal dogs.

5. The oxygen pressure and carbon dioxide pressure may be important factors in the regulation of the cardiac output.

6. Thyroid extract should be used with caution in myxœdematous patients presenting evidence of cardiac weakness and withheld when cardiac decompensation supervenes.

7. Iodine therapy is valuable for a time in patients with hyperthyroidism, and especially so in patients with pronounced cardiac symptoms.

8. The prolonged administration of iodine is probably useless.

9. The administration of digitalis is indicated in hyperthyroidism.

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LATENT POSTOPERATIVE TETANY

By H. M. RICHTER, M.D., F.A.C.S., Chicago
Professor of Surgery Northwestern University Medical School; Attending Surgeon, Wesley Memorial and Mt. Sinai Hospitals
AND
L. M. ZIMMERMAN, M.D., Chicago
Clinical Assistant in Surgery, Northwestern University Medical School

POSTOPERATIVE tetany is usually thought of as one of the infrequent complications following thyroidectomy, and its occurrence is so rare that only isolated reports are to be found in the literature. Von Eiselsberg (9) states that in 2,588 goiter operations, he has had 6 fatal cases of tetany, 8 "severe" ones and about 24 which he calls "mild," a total incidence of slightly more than 1 per cent. A review of the literature (24) relative to the frequency of postoperative tetany reported from the various clinics discloses figures ranging from 0.2 to 3.4 per cent, the average incidence being about 1.4 per cent. Lahey (15) states that in 500 thyroid operations prior to 1921 he had no cases of tetany, in 342 operations during 1921 there were 2, and in 128 operations during the first part of 1922 he had 1 case. In 2,203 operations on the thyroid gland De Quervain (3) reports no case of outspoken tetany, and but 3 cases of "mild, functional parathyroid disturbance." The statistics for our clinic were in accord with those of the other groups cited. We have examined records of 174 thyroidectomies performed prior to September 1, 1924, and found but 2 cases of postoperative tetany, an incidence of 1.15 per cent, which compares favorably with the incidence mentioned above.

In September, 1924, a patient with exophthalmic goiter was operated upon, rather complete resection was done, only a very small amount of thyroid tissue being left behind. She had very little postoperative reaction. On the day following the operation she complained of some tingling in her left hand and examination revealed Chvostek's and Trousseau's signs to be positive. Another post-thyroidectomy patient in the hospital at the same time, who complained of no symptoms whatsoever, was also tested for evidence of parathyroid insufficiency, and in her case too, both Chvostek and Trousseau tests were positive. Both patients apparently had relative parathyroid deficiency yet neither displayed the usual manifest symptoms of tetany. Mild subjective symptoms were present in the first case, none whatever in the second. Both were truly latent so far as spastic phenomena were concerned. Since that time all goiter subjects have been examined before and after operation for similar manifestations, and a surprising number showing positive results have been observed.

For the purpose of this study we have examined 100 consecutive cases operated upon for goiter, beginning with the cases mentioned above. Fourteen of these showed evidence of latent tetany as measured by the presence of a positive Chvostek or Trousseau reaction, or both. The incidence in the various types of goiter was as follows:

	Positive reaction	Per cent
66 exophthalmic goiters	10	15
25 toxic adenomata	3	12
9 non-toxic goiters (adenomata, etc.)	1	11

Signs of parathyroid insufficiency were frequently found to be transitory, and varied greatly in their time of onset. Many patients were examined but once, and this examination was made at varying intervals after the operation. Undoubtedly, had our observations been made with greater regularity and repeated more often, the number showing signs of latent tetany would have been materially increased. Our studies included examination for Chvostek's and Trousseau's signs and blood calcium determinations. In a few cases, the electrical excitability was measured according to Erb. In a general way, where Chvostek's and Trousseau's signs have been present, the electrical irritability

has been correspondingly increased. Erb's sign, however, is more delicate than the others mentioned, and in similar groups of cases reported from other sources, the number of cases positive to Erb's exceeds those positive to Chvostek or Trousseau. In some of the cases definitely positive, a fall in the blood calcium could be demonstrated, but on the whole, there were no striking differences in the calcium levels in tetanic and non-tetanic cases . Apparently, though sufficient parathyroid damage was done to cause an increase in the nervous excitability, it was not sufficient grossly to disturb the calcium metabolism. This would appear to indicate that the calcium deficiency is one of the associated phenomena rather than the actual cause of tetany, and that definite signs of tetany indicating relatively mild parathyroid insufficiency may be obtained without perceptible change in the calcium levels.

In many of our latent cases, the tetany was transitory, disappearing after a shorter or longer period. In 2 cases, however, symptoms became "manifest," and developed later into active tetany, but fortunately were never of a severe grade. It is because of this ever-present possibility that latent postoperative tetany must be considered a condition of prime importance. These patients have apparently sufficient active parathyroid substance to meet ordinary demands, but change of season, trauma, infection, menstruation, pregnancy, or lactation may at any time provoke active tetany. In some cases the condition gradually becomes worse, without apparent exogenous cause, the parathyroid damage apparently increasing as cicatrization progresses. Since it is impossible at the outset to predict the subsequent course, it is extremely important that these latent cases be recognized and proper prophylaxis and treatment be instituted.

The phenomenon of latent tetany following operations on the thyroid gland was discussed by Melchior in 1922 (21). He called attention to the great number of "hungerosteopathies" immediately following the war, in which there were skeletal diseases associated with deficient calcification. From their apparent relation to improper calcium metabolism, from the association of tetany and rickets in infancy, from the tendency in pregnancy to both tetany and osteomalacias, and from the simultaneous increase in these bone diseases and in spontaneous infantile and adult tetany, he reasoned that there was a heightened "Tetaniebereitschaft," a latent tetany, due to faulty calcium metabolism from poor nutritional conditions. In such a state, many injuries which produce no effect on the normal nervous system may provoke manifest tetany. This is especially true in goiter operations, where injury to the parathyroid is most apt to occur. To this fact he attributes the frequently observed increase in postoperative tetany in the period shortly after the war. He first observed tetany in 2 cases which had remained latent for a number of months. In the first case the tetany was noted during the course of examination for re-operation, in the second acute tetany suddenly developed 4 months after the operation, and the patient died. On the strength of his theory and in view of these 2 cases, he tested for latent tetany before and after operation in a series of thyroid and non-thyroid cases (17). Non-thyroid cases gave positive signs (Erb's; Chvostek's) pre-operatively in about 9 per cent of the cases and postoperatively in 30 per cent. Thyroid cases were positive after operation in at least 85 per cent of the cases (Chvostek, 52 per cent). Melchior states that the incidence of tetany in different clinics depends on the method of examination, and that the condition is usually diagnosed only in the severe, manifest forms.

Syring (28) examined his thyroid cases before operation for evidences of parathyroid insufficiency. He found a surprising frequency of such manifestations as the positive Chvostek and Erb signs, and evidences of old rickets, etc. The signs were positive though unusually mild in 25, 47 per cent, of 53 men; and in 40, 54 per cent, of 74 women.

Jatrou (14) of the Eiselsberg clinic studied 71 goiter subjects before and after operation for Chvostek's phenomenon, feeling that the other signs paralleled this one. Of the 71 cases, 14 showed positive reactions before operation; 23, 32.4 per cent, showed positive reactions after operation.

In a recent article, Steichele and Schlosser (27) were unable to confirm the findings reported above. One hundred patients were studied before and after operation. They concluded there was no predisposition to tetany before operation and that postoperatively, there was no "latent" tetany in cases without manifest tetany.

We have been able to demonstrate positive Chvostek or Trousseau signs before operation in a few cases, but the percentage of positives is not nearly as great as those cited above. Of the patients studied, pre-operative parathyroid insufficiency was seen in 3. Of these, 1 had been operated upon elsewhere 11 years before, unilateral lobectomy having been done. She was unable to recall ever having had any symptoms suggestive of tetany. When she presented herself to us because of an adenoma of the opposite side which was causing toxic manifestations, both the Chvostek and Trousseau reactions were found definitely positive. After the second operation, the Chvostek and Trousseau reactions were still positive, but the reactions were less marked and more delayed than before. In 2 other cases the reactions were mildly positive before operation and entirely negative after operation. These findings were probably due to the dietary regime described later. Among those thyroid patients who did not come to operation, 2 were found to have a positive Chvostek sign. One was an extremely toxic exophthalmic goiter patient who entered the hospital moribund, in coma, and died within 36 hours. Autopsy was not permitted. The other occurred in a patient with non-toxic goiter in which surgery was not indicated. In the first case the tetany was apparently due to injury sustained during an earlier operation, in the second it may have been associated with the intense intoxication from which the patient suffered. For the 3 other cases we have no ascribable cause. Obviously, the impaired nutritional state prevalent in central Europe during and immediately after the war, to which Melchior (21) attributes his cases of pre-operative latent tetany, cannot account for our cases.

In our series, the incidence of postoperative tetany varied with the extent of the operation. The size of the goiter seemed to have no bearing whatever. It appears rather that the tetany was an evidence of insufficient parathyroid function due to mechanical operative traumatism. Melchior too was forced to conclude that direct injury does play a rôle, since the frequency of tetany after goiter operations was much higher than after operations on other structures. The mildness and transiency of the symptoms speak against gross, material damage. In none of the thyroid specimens removed from the patients operated upon in the past year have we seen grossly, a parathyroid gland, nor have any of our microscopic sections revealed parathyroid tissue. It is much more probable that the symptoms are due to slight injury to the glandules, pressure from a hæmostat or inclusion in a ligature, or possibly from pressure due to hæmorrhage or œdema. Interference with the vascular supply of the parathyroid bodies may explain temporary interference with their function, which may be restored when the circulation is again established. Tetanic manifestations appearing late are probably due to injury of parathyroid glands from cicatricial contraction. The growing incidence of tetany is undoubtedly associated with the tendency to more and more radical excisions of thyroid tissue, especially in cases of primary hyperthyroidism. Furthermore, the recent increase of literature concerning the parathyroids and tetany has served to focus the attention of surgeons the world over upon this possible complication after goiter operations. We have shown by our own experience that the incidence of parathyroid insufficiency varies directly with the care in looking for it, since the increase in its incidence from 1.15 to 14 per cent in our cases was accompanied by no corresponding change in the type of case or extent of operation.

All of our patients were operated upon after the same general plan. An attempt was made to preserve only a thin layer of thyroid tissue over the posterior capsule, shaving it off under the eye as the lobe was raised toward the median line. Preliminary to this step, the poles were isolated, clamps grasping the vessels behind and above the upper poles,

but gently crushing their way through the tissues of the lower poles, so as to avoid the structures behind. An attempt was made to leave an estimated 2 to 5 grams of thyroid tissue. All of the patients made a complete recovery from the thyrotoxicosis.

A review of the histories presented by this group of cases places them all in the class of latent or extremely mild active tetany. In some cases the condition remained purely latent, never giving rise even to sensory symptoms, and being manifested only by an increased tonus of the facial or skeletal muscles (Chvostek, Trousseau, Erb), which after a few days or weeks returned to normal with or without treatment. This group of cases is certainly overlooked unless routine examination for parathyroid insufficiency is made after all operations on the thyroid gland. These studies should be made before operation and repeated every day after operation for the first week or 10 days, and periodically after that for several months. Only in this way can we determine the number of goiter subjects in whom we damage the parathyroid apparatus sufficiently to give rise to objective evidence at some time or other. The importance of this group lies in the fact that they may become manifest at a later time, during pregnancy, menstruation, lactation, or in the course of infections or metabolic diseases.

The next group of patients, in the order of the severity of sy nptoms, are those who have in addition to the objective signs mentioned above, certain subjective symptoms of parathyroid insufficiency, but without spontaneous muscular spasm. These symptoms are commonly parasthesia, numbness, tingling in the extremities, a sensation of hands and feet "going to sleep," and frequently a "stiffness" in the muscles of the face. When compression is applied to the arms or legs, a spasm of the hand or foot is elicited (Trousseau's sign). Fatigue, languor, and general mental depression are symptoms due to and frequently not ascribed to this condition. Two of the patients in this series had spontaneous cramps of the hands and feet which were promptly checked by treatment. These, however, should not be included in the group of "latent" tetany cases. In one of these the symptoms persistently recurred. We have had no fatal cases.

The duration is seen to be extremely variable. Often the signs are very transitory, are found in one or two examinations, then disappear never to be seen again. These signs would seem to be due to mild temporary derangements of the parathyroids, from which the patient quickly and completely recovers. In other cases, the signs remain for several weeks or months, during which time a certain amount of dietary and medical management may be necessary to keep the patient free from symptoms. After a lapse of the required interval, during which injured tissues may recover, interrupted circulation be restored, or the function of the damaged glandules be taken over by remaining or accessory bodies, all evidences of latent tetany may disappear. In a few instances the signs have persisted, although the symptoms have gradually subsided. Apparently here there has been permanent injury to parathyroid bodies but the body adjusts itself so that no symptoms are produced under normal conditions of living, even in the absence of all treatment. Should, however, circumstances arise, demanding more than the usual parathyroid action, the latent condition may become manifest and tetany occurs.

Prophylactic treatment of tetany is directed toward preventing operative injury to the parathyroids. When Kocher in 1883 first described "cachexia strumipriva," total extirpation of the thyroid was abandoned and less radical resections were substituted. The frequent recurrences, however, and the unsatisfactory cosmetic results led to more and more radical removals with a corresponding increase in tetany. In 1900 Vassale and Generali demonstrated that tetany was due to parathyroid insufficiency rather than to loss of thyroid, and since that time many procedures have been suggested to spare these bodies. As early as 1889, Kocher advocated leaving the posterior layer of thyroid tissue, and it has been a routine procedure with most surgeons since that time to leave the posterior capsule and a

thin layer of gland tissue intact. De Quervain (3) feels that ligating the inferior thyroid arteries close to the capsule of the gland, in the region of the arterial branches to the parathyroids, further jeopardizes the glandules. He recommends that the "danger zone," including the upper pole and the posterior capsule, be spared with a minimum of handling or exposure. In addition, he ligates the inferior thyroid artery away from the gland, close to its origin from the carotid. Syring, too, considers the ligation of all four arteries a source of danger and in the presence of a predisposition to tetany, releases the ligature from one of the vessels after the stump has been sutured. Eiselsberg, Grasman, Madlener (19) and others also avoid ligating all four vessels, although they consider it a matter of minor importance. Maier (20), Floercken and Fritsche (11), and others disregard the matter of ligating the vessels, and ligate the four arteries without hesitancy.

Charles Mayo has suggested the "subcapsular" resection, in which the gland is lifted and the vascular branches are ligated within the capsule. W. S. Halsted (13), too, advocates this "ultra-ligation" method. His method of delivering the gland, controlling hæmorrhage, and protecting the parathyroid bodies and recurrent laryngeal nerves, published nearly 20 years ago, has not been improved upon.

In spite of the greatest care, injury to the parathyroids may occur during operations on the thyroid gland. The location and number of parathyroid glandules is extremely variable, and in the presence of goiter the displacements from the "normal" positions are even greater. Proper resection in toxic goiter, in view of modern ideas on thyroid surgery, demands radical excision of both lobes of the thyroid, leaving behind only a few grams of gland tissue. In a general way we recommend that care be taken in the handling of the tissues, and that particularly the posterior layer of thyroid tissue be preserved. In spite of the greatest precautions, however, if thyroidectomies are made sufficiently radical, there will be a certain number of injuries to the parathyroid glands.

Active treatment has followed two main principles, the relief of symptoms and the replacement of lost tissues. MacCallum (18), in 1909, called attention to the specific therapeutic value of calcium in tetany, and since that time, the administration of calcium salts has constituted the most widely used and until recently, the most uniformly efficacious remedy in the control of tetanic conditions. It was formerly believed that calcium has the power to alleviate the symptoms for a time only, but now it has been shown (Luckhardt) that animals can be kept alive indefinitely by its use. The failures in the past, in the use of calcium have undoubtedly been due to the employment of much too small doses. Luckhardt and Goldberg (17) found that in completely thyroparathyroidectomized dogs 1.5 grams of calcium lactate per kilogram of body weight every 24 hours, was necessary to control tetany. Clinically, the lactate is most frequently used, and it is administered orally, but in severe, threatening cases it may be given intravenously, with almost immediate relief from convulsive symptoms. All symptomatic treatment strives to tide the patient over the acute stage of parathyroid insufficiency, until the apparatus has recovered or regenerated, or until the body has adapted itself to the loss. In experimental animals, 4 to 6 weeks usually suffices for the organism to recover from the tetany following complete extirpation of the parathyroids. After this time, they are able to get along on stock diets under ordinary conditions, without symptoms. During œstrus, pregnancy or lactation, however, they may again present evidences of tetany.

Replacement therapy has been attempted, experimentally and clinically, since the rôle of the parathyroids in tetany was shown. Fresh and desiccated glands, extracts, and even thyroid substance have been administered both by mouth and hypodermically. Most observers have found the oral administration of parathyroid substance of no avail. Pool (26) and Eiselsberg, independently and within a few weeks of each other, transplanted parathyroids in the treatment of postoperative tetany. Since that time, conflicting reports as to the effectiveness of this

procedure have appeared. Certain inherent difficulties render the transplantation of parathyroid glands a rather inexpedient method, one to be reserved as a last resource.

The obtaining of material for transplantation is the greatest difficulty. Isotransplants, in the hands of Borchers (1), Munroe (25) Floercken and Fritsche, and others have given gratifying results. To obtain fresh human material is a matter of considerable difficulty. The deliberate removal of parathyroids from one person to implant in another strikes us as being unjustifiable, and the use of glands from recent corpses or still-born children is not always feasible. The further difficulty of recognizing parathyroid glands, with certainty, in the gross, without microscopic control should also be mentioned. Isotransplants, the immediate re-implantation of any parathyroid bodies found in the specimens removed at operation, are advocated. Lahey (16) carefully examines every thyroid removed for such glandules and feels that their re-implantation is of considerable value.

Accepting the theory that the parathyroids constitute a part of the detoxicating apparatus, and that tetany represents an intoxication from failure of this protective mechanism, Dragstedt (4) has shown that the responsible poisons arise chiefly from the gastro-intestinal tract. By eliminating proteolytic putrefaction in the colon he has been able to carry his animals along until they have recovered from the loss of their parathyroids. He employed a meat-free diet, gave an abundance of milk, and prevented constipation. On the basis of this work and that of Luckhardt and of Retger and Cheplin, we have developed a pre-operative and postoperative dietary regime which we employ routinely in all goiter cases.

DIETARY REGIME[1]

1. Patients are placed on a high caloric, meat free, or meat poor diet.

2. Usually, they receive 1,000 cubic centimeters of milk and from 200 to 300 grams of lactose daily. This combination will change the colon flora to that of an aciduric type in 3 to 4 days. The lactose is at times rather difficult to administer. It is given in various foods—ices, candy, ice cream, etc. It is also more readily given in wafers.

3. When the lactose tends to produce colic and diarrhœa, chalk, kaolin, or bismuth are added.

4. When lactose is definitely objectionable to the patient, the milk culture of the acidophilus organism 1,000 cubic centimeters daily, makes a perfect substitute and is pleasant to most patients.

5. Milk alone, 1,000 cubic centimeters daily in combination with a meat free or low meat diet, is fairly satisfactory in accomplishing the same purpose.

6. Carbohydrates other than lactose are given freely for their caloric value. None of these have any effect on the character of the intestinal flora, except dextrin, which has value equal to lactose, but is more difficult to administer.

7. Liquids are pushed. Pitchers of water and fruit juices are kept constantly at the patient's bedside.

After operation the patient continues on the same regime until some days have elapsed, when he gradually resumes his normal diet in the absence of signs of parathyroid damage. Should parathyroid damage become evident, this dietary regime is maintained and further treatment is prescribed as follows:

The diet is made definitely meat free. Calcium lactate is given in 30 to 60 gram doses daily. Liquids are pushed to the extreme. Before the advent of Collip's parathormone, in one patient whose symptoms reached the stage of some facial and carpopedal stiffness, we administered water in 6 to 7 liter doses by means of a duodenal tube, with relief within an hour or two on several occasions.

We have used Collip's parathormone in 3 of the cases listed, with immediate relief in each instance. The dosage must be gauged to meet the severity of symptoms. By following the regime outlined above, the need for parathormone could be entirely obviated in our cases, only one of which was of a severe grade. However, its occasional use in 3 of our patients permitted a relaxation of the severity

[1] Since submitting this paper for publication we have modified this regime somewhat, reserving its strict application for only those cases showing evidence of parathyroid insufficiency.

of the regime which was very gratifying to them.

In one extremely severe case, operated upon elsewhere, there was both a high grade active tetany and complete bilateral recurrent laryngeal nerve paralysis, the combination resulting in asphyxia that at times ended in unconsciousness. The tetany was completely controlled by Collip's parathormone. The patient has now been under our observation 11 months, has been entirely symptom free for 5 months, and the regimen listed above has enabled her to dispense with the parathormone. But a return to a meat diet, or other serious lapse, results in the need for immediate return to the parathormone dosage. We have had no success with, and have entirely discarded the administration of parathyroid preparations other than that of Collip.

SUMMARY

1. Parathyroid damage occurs much more frequently than is usually supposed after goiter operations; in our series it was demonstrated in 14 per cent of the cases.

2. In most of these cases the tetany is purely "latent" and is not detected unless objective examination is made for the signs. Symptoms and signs are for the most part transitory, and probably represent mild, temporary disturbances in parathyroid function.

3. Latent tetany may become manifest, especially during pregnancy, menstruation, lactation, or during the course of infectious diseases.

4. Latent tetany often occurs without demonstrable change in blood calcium levels, and would appear to indicate that fall in blood calcium is an associated and not necessarily an early phenomena, rather than a cause of tetany.

5. Tetany may be controlled by changing the intestinal flora to one of the aciduric type, and by the administration of calcium by mouth. This regime, which presumably prevents absorption of toxic materials liberated in the colon from proteolytic putrefaction, consists of meat-free diet, liquids in large quantities, including at least 1 quart of milk daily, and lactose, 200 to 300 grams in the 24 hours.

6. We have used Collip's active principle of the parathyroid (parathormone, Lilly) with very gratifying results. Its use is desirable in those cases in which clinical manifestations do not disappear within a relatively short period of time.

CASE REPORTS

CASE 1. M. S., a female, 26 years of age, was operated upon for exophthalmic goiter. The patient reacted well. Twenty-four hours after operation she complained of some tingling in her left hand; 48 hours later this had extended to both hands and the face. There was some stiffness of the fingers and cheeks. Both the Chvostek and Trousseau signs were strongly positive.

The symptoms were completely controlled on a dietary and medicinal regime described later, consisting mainly in a meat-free diet, liquids pushed freely, and including a minimum of 1 quart of milk daily, from 30 to 50 grams of calcium lactate and from 100 to 250 grams of lactose daily. Both symptoms and signs reappeared from time to time, but were always easily controlled, disappearing permanently on full diet after 8 months.

CASE 2. Mrs. A. B. P., age 23, with exophthalmic goiter, had prompt and satisfactory recovery from a radical thyroidectomy. Twenty-four hours later she was subjectively well in every way, but gave a positive Chvostek and Trousseau reaction. Subjective disturbance first appeared after several days, consisting of tingling in the fingers and cheeks. Later she was conscious of a stiffness in her cheeks and fingers. This proved to be the most obstinate and serious of our cases, the only one in which the symptoms persisted for over a year. Marked carpopedal spasm was present, with, at times some stiffening of the leg muscles, but she at no time had an actual tetanic convulsion.

The symptoms were usually well controlled by the regular regime, at times with few dietary restrictions. The menstrual periods added but little to her difficulties. She successfully passed through an appendectomy for acute appendicitis. Her condition varied greatly, at times her discomfort reaching a high degree. On several occasions she was given 3 to 4 quarts of water per duodenal catheter with immediate relief.

Collip's parathyroid extract (parathormone—Lilly) gave her relief within 2 hours; usually 2 cubic centimeters sufficed, but occasionally more was required. We have not had the experience of having complete and permanent relief from a single dose of Collip's extract in either this or other cases.

At one time the patient was entirely symptom free for 5 months, then had her most marked disturbance ushered in suddenly by a severe fright—a burglary.

CASE 3. Mrs. B. B., age 40, was operated upon for exophthalmic goiter. This patient remained symptom free and over a period of 7 weeks gave a

negative Chvostek and Trousseau reaction. Three weeks later, 10 weeks after operation, she first complained of tingling in her fingers, and both Chvostek and Trousseau signs were positive. Symptoms were present intermittently for 7 months, always mild. All symptoms and signs disappeared permanently at this time.

CASE 4. Mrs. A. L. W. was operated upon for exophthalmic goiter. The first subjective symptoms appeared 5 weeks after operation, when the Chvostek and Trousseau signs were both present. Both signs had been absent up to the time of leaving the hospital. She became permanently free of symptoms after 4 months.

CASE 5. N. K., age 40, was operated upon for toxic adenoma. Mild tingling was irregularly present over a period of several months. The Chvostek and Trousseau signs, only occasionally present and always mild, were permanently negative after 8 weeks.

CASE 6. Mrs. J. C. P., age 33, had had right lobectomy elsewhere 10 years previously for "simple cystic goiter," and came to us because of adenoma of the left lobe with mildly toxic symptoms. Examination revealed mild Chvostek and Trousseau signs.

Following removal of the remaining lobe, both Chvostek and Trousseau signs were present, but appeared milder than before operation. This patient at no time had any subjective symptoms. The diminution in her reactions may be accounted for by the dietary regime on which she was placed.

CASE 7. Mrs. G. D., age 27, was re-operated upon for exophthalmic goiter, for which a thyroidectomy had been done 2 years previously. She had meanwhile passed through a pregnancy to full term and normal delivery. The Chvostek and Trousseau signs were negative. At re-operation, because of persistence of toxic symptoms, a material mass of thyroid tissue was found and removed.

The Trousseau sign became positive, and subjective tingling appeared within a few days. All symptoms increased, reaching a grade of moderate severity after 3 months. She then reacted promptly to treatment, but was not entirely free when last heard from. This patient's symptoms were exaggerated during menstrual periods, and materially so during an intercurrent respiratory infection.

CASE 8. Miss E. S., age 20, operated upon for exophthalmic goiter, had had fairly extensive X-ray therapy elsewhere. Twenty-four hours after operation, the Chvostek, Trousseau, and Erb signs were distinctly positive, and tingling in the face and extremities was marked. Within 5 weeks all subjective symptoms and objective signs disappeared.

CASE 9. Miss B. K., age 21, was operated upon for exophthalmic goiter. No subjective symptoms appeared at any time. Two days after operation all signs were negative. On the seventh day the Chvostek sign became faintly positive, the Trousseau sign negative—entirely negative 34 days after operation.

CASE 10. H. S., a male, age 36, was operated upon for exophthalmic goiter. Tingling and objective signs became positive 24 hours after operation, but entirely negative within 10 days.

CASE 11. Mrs. D. S., age 40, was operated upon for non-toxic adenomatous goiter, with retrosternal masses producing pressure symptoms. No symptoms were present at any time. The Chvostek and Trousseau signs were negative until the eighteenth day, when the Chvostek sign became positive. The Trousseau sign remained negative.

CASE 12. Mrs. F. S., age 40, had exophthalmic goiter. She had been operated upon elsewhere 17 months previously, a right hemithyroidectomy being done. The hyperthyroidism persisted. Examination was negative for the Chvostek and Trousseau signs. A left hemithyroidectomy was done. Twelve days later a mild but distinctly positive Trousseau reaction was obtained, the Chvostek remaining negative.

CASE 13. Mrs. H. F., age 60, had toxic adenoma, cholecystitis of long standing, and mild hypertension. Thyroidectomy was performed and 7 days later she complained of tingling in her fingers. The Chvostek and Trousseau signs were positive. Sensory disturbances were persistent and disturbing, but never serious.

CASE 14. Miss L. K., age 34, was operated upon for exophthalmic goiter. No record is given of examination for the Chvostek or Trousseau sign until 10 weeks later, when both were found to be distinctly positive. The patient was entirely free of symptoms.

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AN ENDOMETRIAL GROWTH IN THE RIGHT LABIUM MAJUS

WITH A DISCUSSION OF THE ORIGIN OF THIS TYPE OF TUMOR[1]

BY J. STEWART HENRY, M.D., MONTREAL, CANADA

ALTHOUGH the endometrium is normally restricted to the lining of the uterine cavity, it has long been known that it may be found in other situations. Interest in the subject of aberrant endometrial or endometrium-like tissue was in the first instance aroused by von Recklinghausen (36), who claimed for it an origin from embryonic rests derived from the wolffian body. In 1896 Cullen (5) showed that the generally recognized type of adenomyoma of the uterus is due to the invasion of the uterine wall by its mucous membrane, and in his work upon the subject (6) he has conclusively demonstrated that this is the true origin of these tumors. "Adenomyomata" whose glands were of endometrial type have been reported by many writers, notably Cullen (7), as occurring in the rectovaginal septum, and Lockyer (19), who has collected 47 cases of such growths. Some authors have held that they arise from wolffian remains, but Cullen believes that they are of muellerian origin, and arise either from "the uterine mucosa or from remnants of Mueller's ducts" (7). Robert Meyer believes them to be of inflammatory origin and examples of heterotopy, while Lockyer (19, p. 370) "cannot believe that the mature uterine mucosa has ever been *proved* to have provided the gland tissue in any extra-uterine growth wherever situated," and thinks it "much more likely that the peritoneum or vagina is the source of the epithelium in the majority of cases."

"Adenomyomata" of the round ligament containing endometrial glands and stroma, have been reported by Cullen (3), von Recklinghausen (19, p. 271), F. Weber (39), Pfannenstiel (23), Blumer (1), Martin (20), Semmelink and de Josselin de Jong (35), and others (19). Von Recklinghausen cited his case as a proof of the wolffian origin of extra-uterine and extra-tubal endometrium wherever found. Cullen, on the other hand, held that while the wolffian origin could scarcely be disproved, the true origin was probably from muellerian rests. Elisabeth Weishaupt (40) applied the serosal theory of Ivanoff (18) and Meyer (21) to round ligament "adenomyomata," and claimed that they arose by heterotopy and metaplasia of the peritoneum, forming the processus vaginalis or canal of Nuck; while Lockyer favors "arguments based upon developmental research" (19, p. 320), in other words, the wolffian theory.

Growths of a similar nature have been found in the ovarian ligament, and the same theories have been advanced to explain their origin. Charles D. Green (16) in 1899 reported an adenomyoma of the umbilicus, whose glandular elements were uterine in character, and Cullen (10) in 1916 collected 11 cases of this rare lesion.

In 1899 Russell (24) reported the finding of what he regarded as a rare anomaly, namely the presence of endometrial tissue in an ovary, and argued that it arose from the germinal epithelium. Casler (2), Cullen (12), and Norris (22) also reported cases in which ovaries were found to contain endometrial tissue. Up to this time (1921) endometrial tissue in the ovary had been regarded as a decided rarity, and was generally looked upon as arising from the germinal epithelium, or from embryonic rests of muellerian tissue within the ovary.

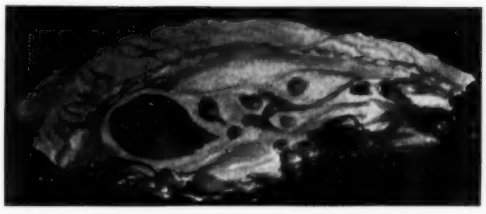

Fig. 1. Photograph of a drawing of the nodule removed from the upper pole of the right labium majus and laid open to show its structure, showing normal skin; large cyst with smooth walls and viscid amber colored contents; and small cysts embedded with the large one in fibrous tissue.

[1] From the Department of Pathology of the Montreal General Hospital.

Fig. 2. Very low power photomicrograph of a section near the periphery of the nodule. *A*, Fibrous connective tissue; *B*, *B1*, *B2*, cystic spaces into which project masses of stroma containing glands. These are the "pseudo-glomeruli" of von Recklinghausen, or "miniature uterine cavities" of Cullen. Is it possible that they are masses of endometrial epithelium and stroma growing in and partly or wholly lining dilated lymph spaces? *C*, *C1*, Typical uterine glands seen in longitudinal and transverse section.

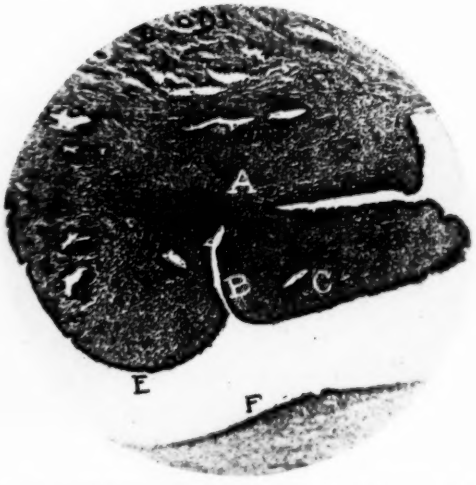

Fig. 3. Photomicrograph of cyst with mass of stroma and glands seen at *B* in Figure 2. The cyst is lined throughout by a single layer of epithelium, low cuboidal where it rests upon the fibrous tissue at *F* and high columnar where it rests upon the cellular tissue at *E*. Cilia have not been demonstrated in this cyst. Two glands whose lining is continuous with the covering epithelium of the mass, dip into the cellular tissue or stroma, *A*. One of these, *B*, shows partial branching of its distal end. A number of glands, some of which are moderately dilated, are seen in the cellular tissue, *C*, between it and the underlying fibrous tissue and in the fibrous tissue itself, *D* and *D1*. The stroma is made up of cells which vary somewhat in size, are polygonal or roughly oval in form and possess rather large, deeply staining nuclei. There is no evidence of inflammation in the stroma, nor are any fragments of elastic fibers to be found. The capillaries of the stroma are distended and there are many large and small hæmorrhages. Both glandular and stromal elements are identical with endometrium in an early premenstrual stage.

In 1921 Sampson (25) reported 23 cases from his own practice in which he had found endometrial tissue in hæmorrhagic ovarian cysts. In this report he put forward the theory that aberrant endometrial tissue found upon (or in) the ovary or elsewhere within the pelvis, owes its origin to the implantation and growth of uterine epithelium, which in a comparatively large number of women, escapes, together with menstrual blood, from the fimbriated ends of the fallopian tubes. In succeeding communications (26, 27, 28, 29) he has elaborated this theory, and at the present time it is accepted by many authorities as explaining the origin of intrapelvic endometrial "adenomyomata," although some still prefer the older theories of embryonic and serosal origin. It may safely be said that the theory of endometrial implantation offers the most rational explanation of these growths, and accounts for their location, the astonishing frequency of their occurrence, and their morphological and functional identity with endometrium.

Although, thanks to Sampson's writings, we are beginning to recognize the frequent occurrence of what he called "ectopic endometrial growths or implants" within the pelvis, extrapelvic growths containing endometrial tissue are decidedly uncommon. The following is one in which a nodule removed from the upper pole of the right labium majus proved to contain such tissue.

Mrs. S. (M. G. H. 5101–24), aged 42, was admitted to the Montreal General Hospital, complaining of a swelling in the right labium majus. Her menses began at the age of 13 years, were always regular, every 28 days, lasting 2 to 3 days, with a moderate flow and very slight dysmenorrhœa. Thirteen years ago, at the age of 29, she had a miscarriage, and since then she has had two full-term children, the

Fig. 4. (See Fig. 2, *B*). A low power photomicrograph of part of field shown in Figure 2. It shows the relation of the fibrous tissue of the nodule to some of the masses of stroma. Note the high columnar epithelium at *A*.

Fig. 5. A low power photomicrograph of the cyst shown at *B1* in Figure 2. *A*, Endometrial stroma; *B*, a characteristic endometrial gland, its distal extremity is slightly forked and contains free red blood cells; *B1*, a dilated gland; *C*, very high columnar epithelium lining the cyst and here lying directly upon fibrous tissue; it is slightly lower at *C1* and *C2*.

last 10 years before operation, both instrumental deliveries. Three years prior to operation she noticed a small hard nodule in the upper part of the right labium majus, since when this nodule gradually increased in size, and a short time previous to admission she noticed a second small nodule close to the first. The nodules were tender at all times, and from the first became swollen and painful at each menstruation. Latterly the swelling and pain were felt 1 or 2 days before each period and reached a maximum on the third or fourth day, then faded away and reached the premenstrual size and condition after about 9 or 10 days. She had noticed that when the nodules were swollen and painful coughing or sneezing caused an increase in the pain, and her clothing irritated them. Examination showed a nodular swelling about the size of a walnut, situated in the substance of the upper extremity of the right labium majus. It was fairly firm, and movable in and over the surrounding tissues. There were no signs of inflammation about it. Examination of the pelvis was negative. The patient was operated upon 2 days before she expected to menstruate. The mass was removed without difficulty. It did not appear to infiltrate the surrounding tissues, and the round ligament was not encountered.

Pathological report (S–24–1068). The specimen consists of a piece of tissue measuring 5.2 by 3.1 by 1.6 centimeters. It is roughly triangular in cross section, and is covered upon one surface by normal skin. The cut surface exposed by dividing the specimen longitudinally shows one large cyst 1.7 by 1.3 by 1.3 centimeters lying near one pole, and filled with a clear amber colored viscid fluid. Its walls are smooth and white except for a few areas which are of a rather deep orange color. Near this cyst are several smaller cysts, separated by thick white bands, and containing a fluid similar to that in the larger one.

The following description is based on the study of many sections made from various parts of the specimen and stained with differential stains:

Sections taken through the margin of the specimen so as not to include the large cyst, show that it consists of a nodule of fibrous tissue, lying directly under the intact skin, and surrounded by subcutaneous fat and connective tissue (Fig. 1). The fibrous tissue is arranged in an irregular manner, and there is no smooth muscle in the nodule except that of the walls of its numerous blood vessels. In the central and deeper portions a number of cystic spaces of irregular shape are seen, the greater number of which contain projecting masses of a tissue which stains deeply with hæmatoxylin (Fig. 2).

The cysts are lined by a single layer of epithelial cells, which in part lie directly upon the fibrous tissue and in part upon projecting masses of a very cellular and deeply staining tissue. Where the epithelium is in contact with the fibrous tissue it is flat, but where it lies upon the cellular tissue it varies from cuboidal to high columnar. The projecting masses of cellular tissue lie upon the surrounding fibrous tissue which

Fig. 6. A very low power photomicrograph which shows a small part of one end of the large cyst in the fibrous nodule, together with adjacent smaller cysts. *A*, Part of large cyst; *B*, lining of flat epithelial cells lying directly on fibrous tissue; *C*, columnar epithelium overlying the stroma in the wall of the cyst at *D*; *E*, a smaller cyst lying near the large cyst; *F*, projecting tongue of stroma covered by columnar epithelium; *G*, large mass of stroma of very typical uterine character covered by high columnar epithelium and containing dilated glands lined by a similar epithelium; *H*, ciliated epithelium in the lining of a small cyst.

Fig. 7. A low power photomicrograph of the field shown at *G* in Figure 6. It shows very beautifully the typically uterine character of the stroma and the high columnar epithelium covering it. In it are two irregularly dilated glands. No cilia are seen in the epithelium here pictured.

provides a supporting framework for the larger masses. They are made up of cells which vary somewhat in size, are oval or polygonal in form, and stain deeply. In many of the projecting masses, glands are seen dipping down from their free surfaces. These glands are lined by a single layer of high columnar cells, which is continuous with the epithelial covering of the mass. For the most part they are straight tubular glands, but a few tend to branch at their distal extremities. Other glands are seen in cross section, and some of these are of normal uterine character, while others are more or less dilated. In the cellular tissue or stroma about the glands, recent hæmorrhage may be seen, which in some places has involved the gland lumina.

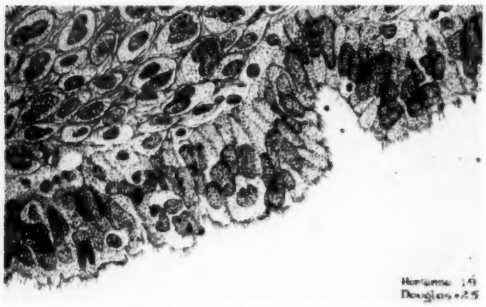

Fig. 8. Drawing of an oil immersion field showing cilia upon the epithelium lining a small cyst which lies near the large cyst, a part of which is seen at *H* in Figure 6.

From the foregoing description and a reference to the figures, it will be seen that the tissue of the projecting masses in both its glandular and stromal elements appears to be identical with endometrium in an early premenstrual stage. In view of the fact that the patient was operated upon two days before she should have menstruated, one would expect to find premenstrual congestion or hæmorrhages in this tissue if it be endometrium, as it appears to be. If a comparison be made between this tissue and the endometrium which invades the wall of the uterus in adenoma diffusum benignum, the identity of structure is most striking. (For a further description see legends under Figs. 3, 4, and 5.)

The greater part of the circumference of the large cyst is lined by a rather thick wall, the outer layers of which are made up of dense fibrous tissue. Near to the lumen of the cyst, the fibrous tissue cells are less mature, and white blood cells are caught in their meshes. The inner layer of the cyst wall is for the greater part very irregular in outline, and is made up of young fibroblasts, white blood cells, plasma cells and endothelial leucocytes. The plasma cells and endothelial leucocytes contain granules of brownish pigment, some being completely filled with the pigment granules, which are taken to be blood

pigment derived from old hæmorrhages. There are also here and there collections of fresh red blood cells. At one end of the cyst there is an incomplete epithelial lining which is flattened where it lies upon fibrous tissue, and high columnar where it rests upon a layer of stroma. The stroma here, as elsewhere, contains evidence of recent hæmorrhage and is of uterine type (Figs. 6 and 7). Several small cysts lie close to the end of the large one, and in general structure present the same appearance as those already described. In one of them cilia can be plainly seen (Fig. 8).

Further sections taken from different parts of the nodule present appearances similar to those described, viz.: cystic spaces of varying size, lined wholly or in part by an epithelium which lies partly in contact with the fibrous tissue where it is generally flattened, and partly upon projecting masses of stroma, where it is high columnar in type, and in places ciliated. Uterine glands, both normal in contour and dilated, are scattered throughout the fibrous tissue, and occasionally rest directly upon it, but by far the greater number have a mantle of uterine stroma about them. The masses of stroma which project into the cysts contain typical uterine glands, and fresh hæmorrhages are seen between the stroma cells and within some of the glands. The nodule is therefore an adenofibroma containing uterine glands and stroma, and in all essentials corresponds to the intrapelvic "ectopic" endometrial growths. Its endometrial character and origin are further evidenced by the finding of recent hæmorrhages and signs of old ones scattered throughout the glandular and stromal elements.

The smaller cysts with their projecting masses of stroma and epithelial lining correspond to the "pseudoglomeruli" of von Recklinghausen (36, 37, 38), which he considered to be evidence of their origin from the wolffian body. They are also identical with the "miniature uterine cavities" which Cullen (7, 8, and 9) describes (Figs. 2 and 6).

A comparatively small number of cases similar to the foregoing have been reported, and all have been grouped together as "adenomyomata" of the round ligament. Such "adenomyomata" have been reported as occurring in three sites, namely (1) intraperitoneal, (2) within the inguinal canal, and (3) outside the external abdominal ring in the upper pole of the labium majus. No attempt has been made to collect all the reported cases, but the following will serve to illustrate "adenomyomata" more or less intimately associated with the round ligament in each of the three possible locations.

The first case to receive critical study was that reported by Cullen in 1896 (3). The patient was 37 years old, and had been married 13 years. For *about* 8 years before coming under observation she had been aware of a small nodule in the right inguinal region. Seven years before she had had an instrumental delivery. The nodule was painful, and increased in size and became more painful during menstruation. It had grown slowly, especially during the last 2 years. It was situated in the upper part of the right labium majus and was firmly fixed to the deeper tissues. At operation the nodule was found to be firmly attached to the right round ligament, which contained a second smaller nodule within the inguinal canal. Of these only the first was examined microscopically. It measured 3.5 by 3 by 2 centimeters, and was made up of a dense network of interlacing bundles of smooth muscle fibers, and contained many glands lined by a columnar epithelium, and for the most part surrounded by a cellular stroma, though in a small number the epithelium lay directly upon the smooth muscle. Both glands and stroma were of the uterine type. There were also several "miniature uterine cavities" corresponding to the "pseudoglomeruli" of von Recklinghausen. The lining epithelium of these cavities was low cuboidal where it lay directly upon the smooth muscle and high columnar where it lay upon the projecting masses of stroma. The patient had just passed her last menstrual period by 3 days when she was operated upon, and recent extravasations of blood were found in the stroma of the glands and of the "miniature uterine cavities."

From the history of increase in pain and in the size of the nodule at the menses, the similarity in structure and function between its glands and those of the endometrium, and especially the similarity of glands and stroma to those found in diffuse uterine adenomyomata, Cullen concludes that the endometrial elements of his case are of embryonic muellerian origin, although he admits the possibility that they might arise from wolffian remains in the round ligament.

Seven months after the first operation, Cullen (4) removed a second nodule from the

same patient. It was of the same structure as the first, and lay just above the pubes on the left side and was attached to the left round ligament.

It will be seen that the case here reported differs from Cullen's case in only three particulars: first, it contains a relatively large cyst, evidently derived from a "miniature uterine cavity," though its epithelial and stromal lining have been largely destroyed by repeated menstrual bleeding, and the resulting distention (26); second, it is not connected in any way with the round ligament; and third, the endometrial tissue lies in a nodule of fibrous tissue.

In 1898 von Recklinghausen described a case in which an "adenomyoma" was found in the base of the right labium majus, attached to the hypertrophic round ligament. Arguing from the developmental connection of the round ligament with the wolffian body, he used this case as a proof of the origin of ectopic endometrium-like tissue from remnants of the wolffian body.

F. Weber (39) described a tumor the size of a hen's egg, situated at the left external ring, and attached to the round ligament. It contained tissue resembling endometrium, and he thought that the epithelial elements arose from the endothelium of dilated lymph vessels.

Pfannenstiel's (23) case illustrated the intracanalicular variety of "round ligament adenomyomata." An unmarried woman, 39 years of age, complained of swelling in the right inguinal region. On examination a second nodule was found in the wall of the vagina. At operation a nodule the size of a walnut was removed from the inguinal canal, just within the external ring, and the vaginal nodule was also removed. Both proved to contain many glands of uterine type and a few "pseudoglomeruli." Pfannenstiel regarded both nodules as being of muellerian origin.

Blumer's (1) patient was a woman 47 years of age, who had noticed for 22 years the presence of two small nodules in the right groin. These grew slowly, and became fused, but in the last 6 months underwent a rapid increase in size. At operation a mass the size of a hen's egg was removed from the right abdominal wall, midway between the internal and external rings, and a little external to the inguinal canal. It was not attached to the round ligament. It was made up of interlacing bands of smooth muscle fibers, and in one section only glands and cysts were found. The glands were lined by a columnar epithelium, in some places ciliated, which lay directly upon the muscle fibers. There was no stroma. The cysts had an incomplete lining of columnar epithelium. It was thought that the tumor might have originated in the inguinal canal from muellerian rests.

The following cases illustrate the intraperitoneal occurrence of these growths. Martin (20) reports the case of a woman aged 71, who had a rapidly growing pelvic tumor. He removed a large cyst containing chocolate colored fluid. It was attached to the left round ligament by a pedicle which contained small cysts with clear contents, one of which was lined with columnar epithelium. Cullen considers this case as being probably an "adenomyoma of the round ligament," but Gottschalk and Schramm (13) believed that it and a smilar case of Schramm's were to be regarded as telangiectatic.

Semmelink and de Josselin de Jong (35) in 1904 reported a case in which all the pelvic organs except the fallopian tubes were infiltrated by endometrium-like tissue. An "adenomyoma" containing a cyst lined with tissue resembling endometrium, arose from the right round ligament, and the authors concluded that upon topographical grounds it must be of wolffian origin—a conclusion with which Lockyer (19, pp. 317–318) appears to agree.

The cases cited are illustrative of a type of growth, be it tumor, the product of inflammation, of epithelial or endothelial metaplasia, or of transplantation, which, situated in more or less intimate relationship with the round ligament, agrees with the others in the possession of epithelial, and in the majority of stromal elements, not to be differentiated from the lining of the uterine cavity. The tumors have this feature in common with the whole group of aberrant or ectopic endometrial growths wherever found. There has been

great divergence of opinion as to their origin, and the question cannot yet be looked upon as being entirely settled. It is reasonable to assume that, since in structure and function all ectopic endometrial growths show a striking identity, they probably have a common origin. Sampson's writings on intraperitoneal ectopic endometrial growths have practically settled the question of the origin of that group. They arise, almost certainly, by implantation of adult endometrial cells carried into the pelvic cavity along with menstrual blood. It is quite in keeping that all other ectopic endometrial growths should also arise from adult endometrial cells. Sampson has found that the intrapelvic growths occur in the vast majority of cases between the age of 30 and the menopause. The case here reported and those quoted all fall between these ages, except in the case of Martin's patient, who was 71, and Weber's, whose age is not ascertainable. Other cases have been reported as occurring before the age of 30 and after the menopause, as was found by Sampson in his series of intrapelvic cases, but the majority have this feature also in common with nearly all of the intrapelvic cases, and this, too, seems to point toward a common origin. It is quite possible that those which occur upon the intrapelvic portion of the round ligament arise by implantation. The intracanalicular cases may also arise in the same way if the processus vaginalis be patent, and have a free opening into the peritoneal cavity; menstrual blood with endometrial cells might conceivably be swept into its opening by intestinal peristalsis.

Implantation does not appear to be as probable an explanation of those cases which occur in the labium majus. Yet it is conceivable that if the skin of the labium were excoriated during menstruation, some cells might lodge in a fissure and grow there, infiltrating the tissues, and producing a nodule of fibrous tissue containing glands. If uterine epithelium were to invade the subcutaneous tissues the natural reaction on the part of the invaded tissues would be the production of a mass of fibrous tissue about the growing glandular elements. It is also conceivable that during instrumental delivery the skin of the labia majora might be traumatized and decidual cells implanted in the traumatized areas. We know that human decidua can be transplanted in abdominal wounds during cæsarean section (34).

There are, however, two other means by which cells from the adult uterine mucous membrane may be carried beyond the limits of the pelvic cavity and give rise to endometrial growths; they may be disseminated through either the veins or the lymphatics of the uterus and their pelvic connections, as Sampson (32, 33) has explained.

In a paper published in 1918, Sampson (31) demonstrated that if uteri were injected with a suspension of bismuth or barium and then X-rayed, the injection mass was retained in the uterine cavity and the tubes, if the uterine mucosa were intact; but if it were damaged as it is after menstruation, parturition, or curettage, the mass passed into the receiving venous sinuses, which lie close to the uterine cavity, and thence to the uterine veins. With this in mind, it is easy to see that during menstruation portions of epithelium or stroma may enter these veins, and be carried by them to any part of the body, and the same may happen following curettage or parturition. The flow of venous blood is in a direction away from the endometrium and this would tend to draw particles of endometrial tissue into the venous sinuses. The uterine veins are devoid of valves and communicate with the vaginal plexus and middle and inferior hæmorrhoidal plexuses, and the latter communicate with branches of the internal pudendal vein which drains the labium majus. Since the pressure in the uterine and other pelvic veins varies considerably and may at one time be negative and at another positive, particles of endometrial tissue could quite conceivably be carried by a retrograde venous flow into the rectovaginal septum, the labium majus, or the round ligament. At all events we know that placental cells are carried in the venous circulation to lungs, liver, and other organs, and that the cells of chorio-epitheliomata are carried in a similar manner, and that metastases of chorio-epitheliomata in the vagina and parametrium are very common.

The uterine lymphatics afford another route by which endometrial cells may reach any part of the round ligament. The endometrium is devoid of lymph vessels, but is richly supplied with lymph spaces, which drain through more definite intramural lymph vessels, into a sub-peritoneal lymphatic plexus, which is especially rich upon the posterior surface of the uterus. A part of the uterine lymphatics is drained via those of the round ligament into the superficial inguinal glands, therefore it is quite possible that epithelial and stromal cells set free during menstruation or after delivery or curettage may find their way into the lymph spaces of the endometrium, and "metastasize" by way of the lymphatics in any part of the round ligament, including its attachments in the upper pole of the labium majus.

In any case, the distribution of ectopic endometrial growths closely resembles that of the metastases of uterine and ovarian carcinoma which originate by transplantation or vascular transportation, and it is logical to assume that endometrial growths may have their origin in exactly the same ways. The endometrium is never stationary, it is constantly being destroyed and repaired; in its destruction a portal of entry is opened up by which its cells may reach either lymphatic or venous channels in the uterine wall, and there is no reason to doubt that it frequently enters these channels and in some cases leads to "metastases" at a distance. Sampson has demonstrated endometrial implantation, and has collected considerable evidence to prove the vascular spread of endometrial cells (32, 33). The writer has recently seen in his (Sampson's) laboratory, a vessel, either a small vein or a lymphatic, in the uterine wall, which contains within its lumen the cross section of a typical uterine gland surrounded by uterine stroma.

It is the writer's opinion that the case here reported owes its origin either to transplantation of endometrial cells into the tissues of the labium majus as a result of injuries received during childbirth, or their vascular (lymphatic or venous) dissemination, more probably the latter. Of the two vascular channels, the lymphatic offers the more direct communication between the uterus and the labium majus, but the possibility of dissemination through the veins, and subsequent growth, cannot be ruled out.

Since the above was written the patient (M.G.H., 5101–24) returned to the hospital, 18 months after her first operation. About 3 months after leaving the hospital she had noticed a small lump in the upper end of the scar; this slowly grew in size and became swollen and very painful and tender at the menses. The pain began about 1 day before the flow commenced and lasted from 10 to 14 days after it had ceased. On examination about 4 days before menstruation, a slight fullness and increased firmness of the tissues of the upper extremity of the right labium majus and right half of the mons veneris was observed. Operation was delayed until menstruation was well established, when the parts referred to presented a marked swelling, which was extremely painful and tender. At operation the mass was found to overlie the deep fascia without infiltrating it, and to extend from the midline overlying the symphysis outward to the external abdominal ring and downward into the labium majus. The distal end of the round ligament was included in the mass and was cut just above where it emerged from the external abdominal ring, and removed with it. The specimen removed measured 4.5 by 3 by 2.5 centimeters, and consisted of firm nodular tissue embedded in fat, from which it could not be shelled out. There was no evidence of a capsule. The cut surface showed many interlacing bands of firm greyish-yellow tissue, enclosing in their meshes small islands of deeply hæmorrhagic tissue and minute cysts whose contents were thin chocolate-colored fluid. Deposits of yellowish or amber-colored pigment were scattered throughout the tissue. Sections show many small islands of endometrial tissue embedded in a dense fibrous matrix. Both glands and stroma are intensely hæmorrhagic and present the typical picture of menstruating endometrium.

Although nothing further has been learned as to the origin of the endometrium in this case, the finding of actively menstruating endometrial elements confirms the previous diagnosis. The finding of the round ligament involved in the aberrant endometrium lends weight to the theory that it took origin by lymphatic metastasis, along the lymph vessels of the ligament. Had it been possible to examine the pelvic organs and peritoneum, further information might have been gained. Ordinary bimanual examination did not reveal any intrapelvic disease.

SUMMARY

Ectopic endometrial growths in the labium majus have been regarded as "adenomyomata" of the round ligament, and their origin assigned to: (1) wolffian or muellerian rests

in the round ligament; (2) metaplasia and heterotopy of the peritoneal endothelium of the processus vaginalis peritonei or canal of Nuck; or, (3) metaplasia of the endothelium of dilated blood or lymph vessels. Sampson, comparing the distribution of ectopic endometrial growths in general with that of the metastases of uterine and ovarian carcinomata, and recognizing their striking similarity, has concluded that the former may, and probably do, originate in the same way as the latter, namely (1) by vascular (venous or lymphatic) dissemination of adult endometrial cells through the uterine veins or lymphatics or both, and (2) by direct implantation of the same within the pelvis. Vascular dissemination probably accounts for the majority of endometrial growths of the round ligament, including its attachment in the labium majus; the lymphatic channel is a more direct one than the venous. It is quite possible that endometrial cells may be implanted in labial excoriations during menstruation, or decidual cells may be implanted if the labia are traumatized during delivery. It is known that both normal human endometrium and decidua can be implanted and will grow in abdominal scars.

The thanks of the writer are due to Dr. David Patrick for permission to report this case; to Dr. L. J. Rhea, director of the Pathological Laboratory of the Montreal General Hospital, for his encouragement and valuable criticisms, and to Dr. J. A. Sampson, who examined sections from the case under discussion and offered valuable suggestions.

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VARIATIONS IN THE PROGNOSIS OF ENDOMETRIAL CARCINOMA AS INDICATED BY THE HISTOLOGICAL STRUCTURE[1]

By W. S. LINDSAY, M.B., Ch. B., Saskatoon, Canada
Department of Pathology, University of Saskatchewan

THE body of the uterus is affected in but a small fraction, usually estimated at about 10 per cent, of all cases of cancer of this organ. In general it may be said that cancer of the body is a glandular carcinoma while cervical cancer is epidermoid. This statement, however, is not absolute. Glandular carcinoma occurs not infrequently in the cervix and epidermoid cancer is found, though but rarely, in the fundus.

There is a tendency to regard carcinoma of the body of the uterus as a clinical entity and to give a prognosis and to carry out treatment on this basis. The duration of symptoms, the possibility of extension of the disease into the parametrium, metastases, and the general condition of the patient are carefully taken into account; but once the diagnosis of cancer has been verified in the laboratory, little or no interest is taken in the histological findings. This neglect is shared by the pathological and gynecological textbooks, many of which, though they give a histological classification, fail to point out its important bearing on the conduct and outcome of the case. As a result the disease is generally regarded and treated as one of uniform type.

This belief has persisted in spite of the fact that it is contrary to both surgical and pathological experience. It has long been known that in certain cases curettage may show undoubted cancer and yet with no other treatment the patient has remained well and shown no further evidence of the disease. Ladinski (7) has collected 22 such cases and many others are found in the literature. In contrast with this and in spite of an immediate operation in which the most complete removal is carried out, many cases quickly show recurrence and end in the death of the patient. On the pathological side is a similar variation. At one extreme are cases in which the departure from the normal is so slight that the diagnosis actually may be in doubt. At the other the picture is that of a rapidly growing, infiltrating, highly malignant tumor. As a result of the merging in a single group of the relatively benign and the highly malignant, an entirely false conception of fundus carcinoma has developed and the more malignant forms are treated with a leniency unwarranted by the facts. Also many patients with the more benign forms are subjected to a severe operation which would appear to be unnecessary.

The object of this investigation, therefore, was to make an attempt to correlate the pathological findings with the subsequent history of the case and so to evolve a practical classification which would be of value both to the pathologist and to the clinician and would indicate to the latter the probable course to be anticipated in any particular case. Unless such information followed, a purely histological classification would have little practical value.

Such attempts at classification are by no means a recent development. Selberg (11) reviews the early work and ascribes the first mention of adenoma malignum to Gusserow (3) in 1870. Five years later, Olshausen (10) described this condition and advised its definite separation from adenocarcinoma. Opposition to this separation was voiced by Kaufmann (5) but Selberg, after reviewing Kaufmann's evidence, came to the conclusion that he had wrongly classified the material on which he based his objections. Selberg described the typical appearance of adenoma malignum and showed that it was definitely malignant, invading surrounding tissues, ulcerating, and producing metastases. He affirmed his belief in the validity of the separation. In the same year, 1900, von Hansemann (4) appeared in opposition and while he admitted the convenience of the term he came to the conclusion that adenoma malignum differs in no way from carcinoma and does not deserve to be elevated to a special class. He also

[1] From the Pathological Laboratory of Memorial Hospital, New York.

maintained that, in general, histology does not give a guide to the degree of malignancy. Von Hansemann's ideas seem to have received wide acceptance and 14 years later Frankl's (2) discussion of adenoma malignum agrees in all essentials with von Hansemann's views.

Recently, however, a new interest has been taken in the correlation of the histological findings and the clinical results of many types of cancer and some success has been attained. Mahle (8) in a very careful and thorough review of 186 cases of fundus carcinoma treated at the Mayo clinic, by estimating the amount of tissue differentiation observed, divided his cases into 4 grades. In Grade 1, which showed the least departure from the normal, no deaths occurred. In Grade 4, showing extreme departure, every patient died. A relation between histological structure and the clinical progress of the case therefore existed. This was essentially a quantitative estimation of the degree of malignancy.

In the present study the attempt has been made to find some qualitative point of differentiation. For this purpose an examination was made of all cases of fundus carcinoma treated in the Memorial and New York Hospitals since 1917. Only those cases have been omitted in which histological material was not available or in which, owing to the disappearance of the patient after treatment or for other reasons, a record of the progress of the case could not be obtained.

At the Memorial Hospital, radium and roentgen-ray therapy has to a certain extent replaced radical operation and as a consequence, in the majority of cases, histological material only has been available. In some respects this has hindered the study and rendered it incomplete. It has, however, this advantage, that the material corresponds exactly to that available to the pathologist at the time that he is called upon to make his critical diagnosis.

Histological examination of sections of fundus carcinoma shows a wide variation in structure and makes it possible to separate from the main mass of cases three definite groups which, though not very large, can be considered distinct diseases. These are adeno-acanthoma, adenomyocarcinomatosis, and embryonal carcinoma.

Adeno-acanthoma (Fig. 3) shows a combination of glandular and epidermoid epithelium, the latter believed to be derived by metaplasia from the superficial epithelium lining the body cavity. Cell nests are not uncommon and produce a very characteristic picture and rarely the differentiation may be so complete that prickle cells are found.

Adenomyocarcinomatosis covers a distinct group of cases in which the malignant process arises in a previously existing adenomyomatosis. The histological diagnosis of this disease from curettings is difficult, often impossible, and in such circumstances a diagnosis of adenocarcinoma will probably be made. Usually recognition of a case of adenomyocarcinomatosis is made only after the removal of the uterus. The organ is large and on naked eye examination may show no evidence of the disease beyond a slight roughening of the endometrium. But on microscopical examination carcinomatous foci are seen extending between the very cellular muscle fibers throughout the whole uterine wall. The disease probably arises from a focus or foci of adenomyoma deep in the muscle wall; therefore, by the time it reaches the endometrium and gives rise to symptoms, the whole wall is permeated often to the peritoneal coat.

Embryonal carcinoma (Fig. 4) also forms a small but definite group. It is composed of sheets of closely packed round and polyhedral cells which are small and contain large darkly staining nuclei and little cytoplasm.

These three groups include only a few of the cases, the majority consisting of tumors of definitely glandular structure. At one extreme are the almost completely differentiated types in which the carcinomatous nature is indicated by the increase of glandular tissue with diminution of the stroma, the increased and irregular size of the cells, and the hyperchromatic nuclei. At the other extreme differentiation is slight and the tumor is composed of solid masses of highly atypical cells deeply infiltrating the supporting structures. Between these two extremes extends an unbroken series of intermediate cases. They may be divided into two groups, adenoma malignum and adenocarcinoma. Ewing (1) further subdivides adenocarcinoma into papillary adeno-

TABLE I.—ADENOMA MALIGNUM

Case number	Age	Gestations	Duration of Symptoms	Treatment	Amount of Radiation				Dead	Alive	Remarks
					Interstitial	Internal	External	X-Rays			
			yr. mo		Millicurie hours				yr. mo.	yr. mo.	
2	32		– 8	Curettage						– 3	
6	69	9	1– 0	Radiation		9903				3– 2	
12	53	0	– 6	Radiation and hysterectomy		6009				3– 3	
15	61			Radiation		3062				5– 0	
17	59	1	– 4	Radiation and hysterectomy	412	1782				5– 5	
19	54	0	1– 2	Radiation		2748				5– 3	
*20	60		4– 0	Radiation and hysterectomy	491	2628				4– 8	Recurrence.
22	55	7	– 1	Radiation and hysterectomy		6914	8934			5– 5	
24	55	0	7– 0	Radiation		3368				4– 9	
26	46	0	1– 0	Radiation and hysterectomy		3276				4– 7	
*27	51	3	4– 0	Radiation and hysterectomy		4469	8844			4– 7	Recurrence.
34	55	2	– 7	Radiation and hysterectomy		1350				4– 7	
*35	46	6	–10	Radiation and hysterectomy		5828		2 x 16′ LV	2–10		Recurrence.
39	54	0	– 3	Radiation		4016				3– 4	
52	42		– 6	Radiation		3163				2– 2	Uterus fixed. Recurred. Further radiation.
53	43	4	1– 0	Radiation and hysterectomy		6024		4 x 15′ LV		2– 6	
54	43	1	– 4	Radiation		2511		4 x 15′ LV		2– 5	
55	52		– 3	Hysterectomy						1– 4	
56	53	0		Radiation		3890		6 x 15′ LV	1– 2		
58	43	0	1– 0	Radiation and hysterectomy				4 x 12′ LV		1– 7	
61	33	1	3– 0	Radiation		8680		4 x 60′ HV		1– 8	
67	64	0	– 3	Radiation		3372				– 8	
*68	52	1	1– 0	Radiation and hysterectomy		3016				– 6	Recurrence.

Cases marked * were operated upon elsewhere and developed recurrences. They then received treatment by radiation. They are therefore cases treated primarily by hysterectomy only and are so classified in Table VI.

carcinoma and alveolar carcinoma. Kaufmann (6) divides the group into adenocarcinoma, papillary adenocarcinoma, and adenocarcinoma solidum. The comparison of the results obtained in these sub-groups showed no definite difference in their prognosis. The separation, therefore, presents no practical advantage at present. Future developments in treatment, however, may show distinct differences in their behavior and justify the classification.

Adenoma malignum (Fig. 1) includes those cases in which the general structure of the glandular elements is everywhere well maintained so that a definite lumen appears surrounded by a single or a double layer of cells. The glands are increased in size and are often thrown into folds to form papillæ and the stroma is decreased allowing adjacent glands to come into direct contact. The cells are enlarged, irregular in size, and hyperchromatic; and mitoses are seen, often in large numbers. But everywhere the polarity of the tissues is maintained. If at any part polarity is definitely lost as shown by the tendency of the cells to form solid masses infiltrating the stroma the case should be classified as adenocarcinoma. This should be done even though the bulk of the tumor has the structure of adenoma malignum. Capacity for infiltration

Fig. 1. Adenoma malignum.

Fig. 2. Adenocarcinoma.

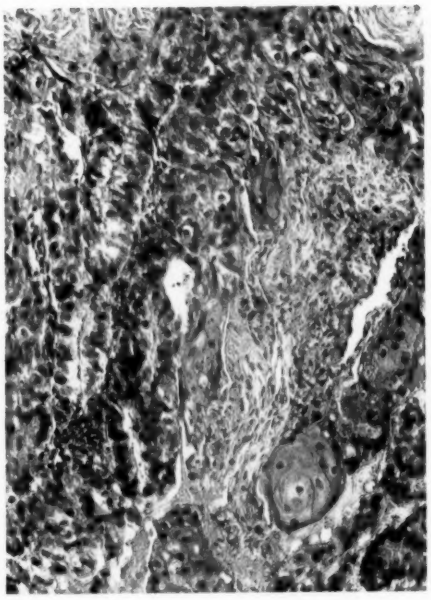


Fig. 3. Adeno-acanthoma.

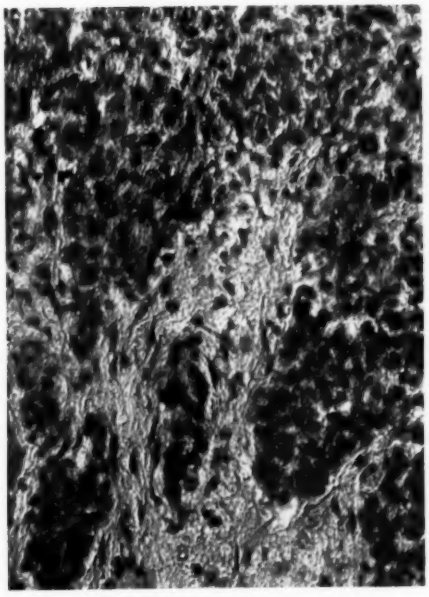


Fig. 4. Embryonal carcinoma.

TABLE II.—ADENOCARCINOMA

Case number	Age	Gestations	Duration of Symptoms	Treatment	Amount of Radiation				Dead	Alive	Remarks
					Interstitial	Internal	External	X-Rays			
			yr. mo.		Millicurie hours				yr. mo.	yr. mo.	
1	45	2	– 2	Hysterectomy					3– 9		
3	60	0	– 5	Hysterectomy					– 5		
7	40	6		Radiation		5168	18150		–10		Inoperable.
10	74	0	– 2	Radiation		1632	17736		3– 7		Recurred. Further radiation.
11	49	5	– 4	Radiation		4896				6– 1	Recurred. Further radiation.
13	57		– 2	Radiation		4000			1– 2		
18	53	3	3– 0	Radiation		6215	13446		2– 5		Recurred. Further radiation.
21	62	0	2– 0	Radiation		3827	9762		3– 1		Recurred. Further radiation.
23	59	7	– 6	Radiation		3595	11922		2– 8		Uterus fixed, left side.
25	54	3	– 3	Radiation		13446			3– 6		Parametrium involved.
28	54	2	2– 0	Radiation		5464		6 x 15′ LV	– 8		
31	40	6	–10	Radiation		5784		2 x 15′ LV	1– 0		Inoperable.
32	62	2	1– 0	Radiation		6280				– 8	Recurred. Further radiation.
33	57	1	1– 0	Radiation		2320			1– 4		Recurred. Further radiation.
38	58	0	1– 0	Radiation		6020		4 x 15′ LV 4 x 17′ LV	2– 7		Recurred. Further radiation.
40	57	6	– 3	Radiation	823	6058				3– 8	Recurred. Further radiation.
41	59	2	1– 2	Radiation and hysterectomy		5124			1– 0		
42	45	2	– 4	Radiation and hysterectomy		2985				3– 4	Recurred. Further radiation.
43	59	0	1– 9	Radiation		4120			1– 8		
44	63	0	1– 4	Radiation		4650			1– 3		
45	57			Radiation and hysterectomy		2418				3– 0	Slightly fixed, left side.
46				Radiation and hysterectomy		4068				– 7	
50	42	1	– 6	Radiation and hysterectomy		4028			– 4		
51	68	6	2– 0	Radiation		9184			1– 9		
57	61		– 4	Radiation		3371		4 x 15′ LV		2– 2	
59	71	8	– 4	Radiation		2662		4 x 15′ LV	– 4		
63	63	6	– 3	Radiation		3360		4 x 15′ LV	– 4		Uterus fixed.
65				Radiation		3648				1– 5	
66	58	0	– 6	Radiation		5800		2 x 15′ LV	1– 2		
70	70	8	1– 0	Radiation		3736				– 9	

TABLE III.—SUSPICIOUS CASES

Case number	Age	Gestations	Duration of Symptoms	Treatment	Amount of Radiation				Dead	Alive	Remarks
					Interstitial	Internal	External	X-Rays			
5	38	3	yr. mo. – 2	Radiation	Mil	licurie hours 1960	19047		yr. mo.	yr. mo. 7– 5	
8	49		– 3	Hysterectomy					– 2		Intestinal obstruction.
9	50	0	– 2	Radiation	2880	3048	16890			3– 4	
14	42	1	– 7	Radiation		1344				– 1	
16	75	7	1– 0	Radiation		1496				4– 7	
48	50		2– 0	Hysterectomy						2– 5	
60	53	2	– 6	Radiation		2706				1– 7	
62	45	4	– 1	Radiation		3135				1– 9	
69	64	3	– 1	Radiation		2570			– 4		Diabetes.

and the loss of polarity are definite evidence of a higher degree of malignancy and the most malignant portion of a tumor should be selected in determining the degree of its malignancy.

Adenocarcinoma (Fig. 2) therefore includes all cases in which there is a definite loss of polarity and infiltration of the stroma by solid cords or masses of cells. It will of course often show other indications of increased malignancy, the cells showing a greater departure from the normal as indicated by greater variations in size and staining, irregular hyperchromatic nuclei, and other evidences of anaplasia. To make a definite line of separation it is necessary to select one characteristic as a criterion and the justification for the somewhat arbitrary selection of loss of polarity and infiltration would appear to be justified by the contrast in the results obtained in the two groups thus separated.

Cases were considered separately when any doubt, however slight, existed as to the malignant character of the process. This was relatively infrequent. As a rule the distinction between carcinoma and the various benign processes was sharp and distinct but occasionally it was thought advisable to qualify the diagnosis by such terms as "suspicious" or "beginning" or to use such a phrase as "atypical adenomatoid endometritis suggestive of carcinoma." All such cases have been considered separately under the heading "suspicious."

For this study, after the elimination of those cases in which histological material or adequate records were unavailable, there remained 70 cases which were classified as in Tables I to IV.

GENERAL MORTALITY

Of the 70 patients observed, 31 (44 per cent) have already died. Taking into account the short period which has elapsed since treatment in many of the cases, this represents a high mortality which is contrary to a commonly accepted belief that carcinoma of the fundus is relatively of low malignancy.

EFFECT OF AGE

Details were available in 67 cases. Arranged in 10-year groups the following distribution was obtained:

Years	Cases
20 and under	1
21 to 30	1
31 to 40	5
41 to 50	16
51 to 60	30
61 to 70	11
71 and over	3

Eighty-five per cent of all cases occurred between the ages of 41 and 70 years, 45 per cent

TABLE IV.—ADENO-ACANTHOMA

Case number	Age	Gestations	Duration of Symptoms	Treatment	Amount of Radiation				Dead	Alive	Remarks
					Interstitial	Internal	External	X-Rays			
			yr. mo			Millicuri e hours			yr. mo.	yr. mo.	
* 4	53	1		Radiation and hysterectomy		5527	17376		-11		Recurrence.
37	57		1- 0	Radiation		2952		4 x 15′ LV	- 5		
47	60	1	- 11	Radiation and hysterectomy		3082				2- 7	
				ADENOMYOCARCINOMATOSIS							
29	49	0	- 9	Radiation and hysterectomy		4170	9216		2- 9		Uterus fixed.
30	26	0	1- 6	Radiation	1575	5027	9012		2- 9		Recurred. Further radiation.
36				Radiation	871	2702		2 x 80′ HV 6 x 15′ LV	1- 4		
				EMBRYONAL CARCINOMA							
19	19	0	- 4	Radiation		2184		4 x 14′ LV		2- 9	
64	55	0	- 2	Hysterectomy					1- 5		

In case marked * the patient was operated upon elsewhere and developed a recurrence. She then received treatment by radiation. It is therefore a case treated primarily by operation.

being in the decade 51 to 60. The average age was 53 years.

The comparison of the age incidence in the different groups of cases revealed nothing of importance nor had the age of the patient any appreciable effect on the mortality.

EFFECT OF GESTATION

Details were available in 56 cases. Of these 20 (36 per cent) were nulliparæ. Norris and Vogt (10) report an incidence of 26 per cent in single women. It would appear, therefore, that child bearing is not an etiological factor.

SYMPTOMS

Hæmorrhage was the outstanding symptom in all groups. Discharge was of second importance, while pain was relatively infrequent. It would appear to be impossible, therefore, to determine the type of the cancer present from an analysis of the symptoms. Coming on as it does at the time of, or shortly after, the menopause with no other symptom than irregular hæmorrhage, the onset of the disease is frequently overlooked. In cases showing hæmorrhage at this time of life, cancer should always be excluded. Pain and cachexia are late symptoms and should be anticipated by a diagnostic curettage.

The dangers of the diagnostic curettage have perhaps received too little attention. It may be taken as demonstrated that cancer cells may be set free in the blood and lymph channels and the danger of metastases increased. There appears to be no way of avoiding this; however, the ultimate danger to the patient must certainly be less than will follow continued uncertainty in the diagnosis.

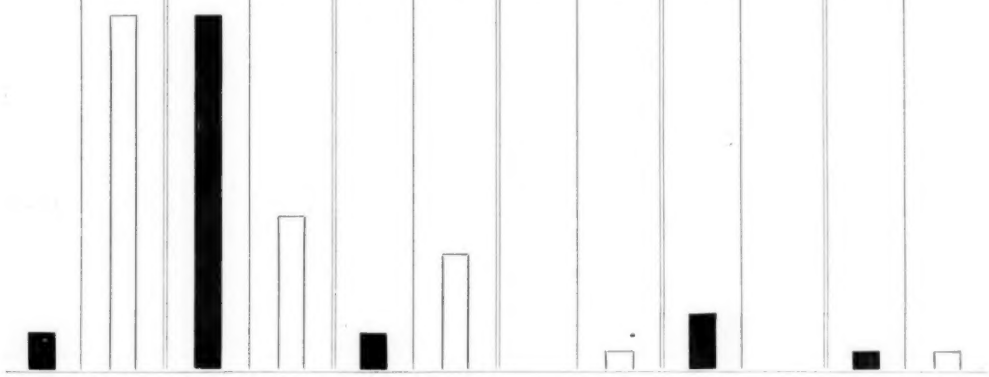
Consideration of the effect of the duration of symptoms previous to treatment on the mortality of the whole series gives at first sight a very peculiar result:

Group	Appearance of symptoms after onset	Mortality per cent
1.	Within 6 months	43
2.	6 months to 1 year	35
3.	1 year to 2 years	80
4.	Over 2 years	44

Group 1 shows a slightly higher mortality than that of Group 2. These paradoxical results are readily explained. The more malignant types produce symptoms quickly and these patients seek medical advice sooner. Consequently, Group 1 contains an undue

TABLE V.—MORTALITY IN ALL GROUPS

Adenoma malignum		Adenocarcinoma		Suspicious		Adeno-acanthoma		Adenomyo-carcinomatosis		Embryonal carcinoma	
Dead	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead	Alive
2	21	21	9	2	7	2	1	3	0	1	1



proportion of the more malignant cases and has a higher mortality. When the cases are considered in groups, it is found as would be expected that the sooner the patient receives treatment the better the results.

RESULTS OF TREATMENT

Before an analysis of results with different forms of treatment is discussed, a comparison may be made of the results in the different groups. In the three small groups, adeno-acanthoma, adenomyocarcinomatosis, and embryonal carcinoma, the cases are so few that little can be learned beyond the fact that the mortality is high. In the others, however, the results are highly significant. Only a few cases have been observed, and some for so short a time that the results cannot be accepted as final. However, the results are taken from cases observed over the same period of years and in the main the treatment in the various groups has been similar; so that while the figures cannot be accepted as having an absolute value, they are at least comparable.

Table V shows a striking difference in the mortality of adenoma malignum and adenocarcinoma. Adenoma malignum is shown to be a disease of low mortality. This becomes even more marked when it is noted that this group includes 4 patients who first came to this hospital on account of recurrences following hysterectomy. One of these cases accounts for 1 of the deaths, the 3 other patients are still alive, the respective periods since the recurrence being 4 years 8 months, 4 years 7 months, and 6 months. To compare these groups fairly, allowance must be made for the short period that has elapsed since treatment in many cases. Of the 23 cases of adenoma malignum, there are 12 three-year cures and 2 patients are dead. Of the 30 cases of adenocarcinoma, there are 4 three-year cures and 21 patients are dead.

There would appear, therefore, to be sufficient evidence to show that adenoma malignum is a much less fatal disease than adenocarcinoma and to suggest that the methods employed have been effective in the treatment of adenoma malignum so far as this can be determined at the present time. In contrast to this, the results in adenocarcinoma have been far from satisfactory.

Table VI shows that out of 10 cases treated by radiation only, 1 death occurred, and in 1 instance a recurrence developed necessitating further radiation. Of the 5 cases treated by hysterectomy only, 4 developed recurrences, and 1 of these died. Among the 7 cases

TABLE VI.—ANALYSIS OF TREATMENT OF CASES OF ADENOMA MALIGNUM
(For details of radiation see Table I)

Radiation only				Hysterectomy only				Radiation and Hysterectomy				Curettage only			
Dead		Alive		Dead		Alive		Dead		Alive		Dead		Alive	
Case	Duration	Case	Duration	Case	Duration	Case	Duration	Case	Duration	Case	Duration	Case	Duration	Case	Duration
56	yr. mo. 1– 2	6	yr. mo. 3– 2	*35	yr. mo. 2–10	*20	yr. mo. 4– 8		yr. mo.	12	yr. mo. 3– 3		yr. mo.	2	yr. mo. – 3
		15	5– 0			*27	4– 7			17	5– 5				
		19	5– 3			55	1– 4			22	5– 5				
		24	4– 9			*68	– 6			26	4– 7				
		30	3– 4							34	4– 7				
		*52	2– 2							53	2– 6				
		56	2– 5							58	1– 7				
		61	1– 8												
		67	– 8												

Cases marked * showed evidence of recurrence and received further radiation.

treated by pre-operative radiation and hysterectomy, no deaths occurred.

In fairness to the simple hysterectomy, it should be stated that the 4 patients in this group showing recurrences (Cases 20, 27, 35, and 68) were operated upon elsewhere and came to this hospital only after the recurrence had already developed. The corresponding successes, of which there probably were a large number, did not require further treatment and, therefore, did not come under observation. The large proportion of recurrences in this group is, therefore, obviously unfair.

That the contrast in the results obtained in cases of adenoma malignum and adenocarcinoma as shown in Table V is not due to differences in treatment is clearly shown by a comparison of Tables VI and VII.

	Adenoma Malignum		Adenocarcinoma	
	Dead	Alive	Dead	Alive
Radiation only	1	9	17	6
Hysterectomy only	1	4	2	0
Radiation and hysterectomy	0	7	2	3

In each case the contrast remains clear.

The question then presents itself—Do these results give us any reason to believe that the less malignant condition, adenoma malignum, might be controlled by less radical measures than are required for adenocarcinoma? Should this be the case it would greatly enhance the value of the differentiation. The number of cases is too small and the time over which they have been observed too short to warrant any dogmatic conclusions but it would seem, as far as can be determined at present, that in a case of adenoma malignum, radiation followed by hysterectomy may be relied upon to eradicate the disease unless of course wide dissemination has already occurred. However, the results following radiation alone are so good and the avoidance of such a serious operation as hysterectomy so desirable that in spite of the single fatality it would seem justifiable to select radiation as the treatment of choice.

On the other hand the results in adenocarcinoma do not appear to justify the use of radium alone in operable cases. Neither radiation alone nor hysterectomy alone has given as good results as have been obtained by their combination. All cases of adenocarcinoma, even those that clinically appear most favorable, should be considered of extreme gravity from the outset and the most thorough and persistent treatment employed.

Suspicious cases. The 2 deaths in this group of cases were due to diseases other than carcinoma. The absence of any cancer mortality shows that the danger is slight in this group when proper treatment is given. Such

TABLE VII.—ANALYSIS OF TREATMENT OF CASES OF ADENOCARCINOMA
(For details of radiation see Table II)

Radiation only				Hysterectomy only				Radiation and Hysterectomy			
Dead		Alive		Dead		Alive		Dead		Alive	
Case	Duration	Case	Duration	Case	Duration	Case	Duration	Case	Duration	Case	Duration
** 7	yr. mo. −10	*11	yr. mo. 6− 1	1	yr. mo. 3− 9		yr. mo.	41	yr. mo. 1−10	*42	yr. mo. 3− 4
10	3− 7	*32	− 8	3	− 5			50	− 4	45	3− 0
13	1− 2	40	3− 8							46	− 7
*18	2− 5	57	2− 2								
*21	3− 1	65	1− 5								
23	2− 8	70	− 9								
25	3− 6										
28	− 8										
**31	1− 0										
*33	1− 4										
*38	2− 7										
43	1− 8										
44	1− 3										
51	1− 9										
59	− 4										
63	− 4										
66	1− 2										

Cases marked * showed evidence of recurrence and received further radiation.
Cases marked ** were considered inoperable from the outset.

cases, perhaps, should be considered as potential rather than actual cancer, the evidence in each case being insufficient to justify an absolute diagnosis. Histological examination shows them to be on the borderline of adenoma malignum and if similarly treated there is little danger to life. Radiation therefore would seem to be the procedure of choice.

Adeno-acanthoma. In this and in the remaining groups the numbers of cases observed are very small but they indicate the gravity of these conditions. In the adeno-acanthoma group are 3 cases. Two patients are already dead. One of these was treated by radiation only, the other by hysterectomy with radiation of a subsequent recurrence. The third treated by pre-operative radiation and hysterectomy is alive 2 years 7 months after treatment. The structure of the tumor shows its relationship to adenocarcinoma and the results of these few cases suggest that a similar rigorous treatment should be adopted.

Adenomyocarcinomatosis. Of the 3 cases in this group all are dead. Two treated by radiation alone died after 2 years 9 months and 1 year 4 months. The third, treated by pre-operative radiation and hysterectomy, died in 2 years 9 months. As already indicated this disease arises deep in the uterine muscle during the course of a previously existing adenomyomatosis. Before any symptoms appear and therefore long before any treatment can be begun opportunity has been given for a widespread dissemination. It therefore offers a very grave prognosis and demands radical treatment.

Embryonal carcinoma is an extremely malignant type but like any embryonal tumor it appears to be sensitive to radiation. Of the 2 cases in this group, 1 (Case 49) occurred in a young woman of 19 years who gave a history of symptoms for 4 months. The other patient (Case 64) was 55 years of age and had had symptoms for 2 months. The expectation,

both from the age of the patient and from the duration of the symptoms, would be that the young woman offered the worse prognosis. She was treated by radiation alone and after 2 years 9 months was reported to be alive and apparently well. The other patient was treated by hysterectomy and died 1 year 5 months after operation. Again the facts are too few to warrant any conclusion but in view of the well-recognized susceptibility of embryonal carcinoma to radiation and the bad results following operation, the outcome is at least suggestive.

Putting aside, then, the rarer tumors of definitely distinct structure the facts brought out in this study would seem to justify the separation of the main mass of cancers of the body of the uterus into two groups which are fairly distinct and have a very different prognosis and which may also demand a different method of treatment. The use of the term adenoma malignum for the less malignant of these groups appears to be justified by its persistence in the literature and in ordinary use over a long period in spite of much adverse criticism and by the fact that it adequately describes the histological picture. That adenoma malignum is essentially a different disease from adenocarcinoma is not evident. The frequent association in the same preparation of areas typical of both would seem to indicate that they are different phases of the same condition. But the essential point to the surgeon and to the patient is that they behave differently and this difference can best be emphasized by the use of distinct terms.

CONCLUSIONS

Cancer of the body of the uterus is a disease of late middle life, the incidence being in the sixth decade (51 to 60 years) following the menopause. Child bearing is not an etiological factor.

After the separation of the distinct types, adeno-acanthoma, adenomyocarcinomatosis and embryonal carcinoma, which are relatively infrequent, the main mass of cases can be divided into two groups, the basis of the division being loss of polarity and the infiltration of the stroma by solid cords or masses of cells. Cases characterized by normal polarity and showing no infiltration are classed as adenoma malignum. Where polarity is lost and there is a definite tendency to infiltration, the case is classified as adenocarcinoma.

In all, 70 cases of fundus carcinoma were studied.

Adenoma malignum (23 cases with 2 deaths) is of relatively low grade malignancy and responds well to treatment. Pre-operative radiation and hysterectomy gave the best results (7 cases, no deaths) but the almost equally good results of radiation alone (10 cases, 1 death) would seem to warrant its selection as the treatment of choice.

Adenocarcinoma (30 cases with 21 deaths) offers a very bad prognosis and demands rigorous treatment from the outset. The best results were obtained by pre-operative radiation and hysterectomy, each of which alone was unsatisfactory.

Suspicious cases of fundus carcinoma showed no mortality due to cancer and appeared to be effectively controlled by radiation alone.

Adeno–acanthoma and adenomyocarcinomatosis have a high mortality and require the same treatment as adenocarcinoma.

Embryonal carcinoma was present in 2 cases only and the results are in conformity with the belief that better results are obtained in this class of case by radiation alone than by operation.

The difference in the behavior of the two main groups, adenoma malignum and adenocarcinoma, justifies their separation. The present tendency to consider as a uniform disease all cases of carcinoma of the fundus uteri is not based on fact and must undoubtedly lead to a uniform misconception of the prognosis and treatment. The adoption or rather the retention of the two groups, adenoma malignum and adenocarcinoma, emphasizes the distinction and tends to secure for each group its requisite attention and treatment.

I wish to express my thanks to Dr. Healy, Dr. Ewing and Dr. Elser for their kindness in placing their pathological material and clinical records at my disposal.

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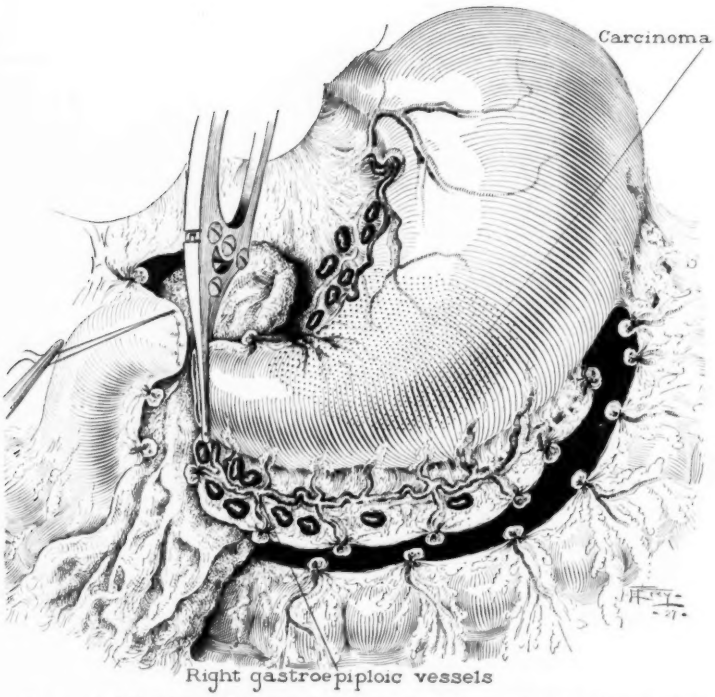


Fig. 6. Mobilization of the stomach. The gastrocolic omentum has been divided and ligated to a sufficiently high point on the greater curvature.

The Technique of Partial Gastrectomy for Cancer of the Stomach.——*Donald C. Balfour.*

CLINICAL SURGERY

FROM THE MAYO CLINIC

THE TECHNIQUE OF PARTIAL GASTRECTOMY FOR CANCER OF THE STOMACH[1]

By DONALD C. BALFOUR, M.D., F.A.C.S., Rochester, Minnesota

PARTIAL gastrectomy, whether for cancer, ulcer, or some of the more rare lesions of the stomach, such as benign tumor, has been developed to a point where the dangers commonly fatal in the past have been practically eliminated. Various methods have been devised to lessen the operative risk and to simplify the technique of the operation. As Halperin has recently pointed out, the methods conform to one or the other of two types: direct anastomosis between the end of the stomach and the duodenum, or closure of the duodenal stump and union of the remaining portion of the stomach with the first loop of the jejunum. The first type is usually called a modification of the Billroth I, and the second a modification of the Billroth II. Many of the methods have survived because of certain merit. I shall not, however, attempt to discuss here their advantages but shall describe in detail the technique of the operation which is customarily carried out in the Clinic for cancer of the stomach, and which is based on the principle of the Billroth II method.

The safety of operation for cancer partly depends on the selection of patients for operation, but a selection based on operative risk will not accomplish the greatest good for the greatest number. The fundamental principle in the surgical treatment of cancer of the stomach is that every patient is entitled to an exploration unless the disease can be proved incurable otherwise. This means that, unless metastasis can be demonstrated or unless the fluoroscope reveals such definite involvement of the cardia that both the experienced roentgenologist and clinician realize that the lesion is irremovable, exploration should be carried out. The observance of such a principle results in a resection of the growth in many instances when patients are in extremely serious condition.

The safety of partial gastrectomy for cancer of the stomach does not depend alone on the manner in which the operation is performed. Since many of the patients are poor surgical risks, no effort should be spared to get them in the best possible condition for operation. Unfortunately, such a progressive disease does not permit of prolonged efforts to improve the patient's general condition, although most gratifying results follow proper pre-operative measures carried out for a reasonable length of time, especially if retention is a complication. Patients with retention should be sent to a hospital, lavage of the stomach carried out, and fluids administered until the dehydration has been compensated. Extraordinary improvement has been effected in a few days in such cases and the mortality has been definitely lowered by the adoption of this routine. It is possible that patients with marked anæmia are benefited by transfusion, although it is difficult to bring about any pronounced change in the hæmoglobin percentage.

ANÆSTHESIA

In operations for cancer of the stomach, anæsthesia is of first importance as a factor of safety. The danger of pulmonary complications is a serious one, not only because the operation is in the upper abdomen but often because of the advanced age and poor general condition of the patient. The duration and character of the general anæsthesia should be the most innocuous possible. Regional block anæsthesia of the abdominal wall, done as a routine, will permit a considerable part of the operation being done without general anæsthesia and, when the latter becomes necessary, it need not be deep or prolonged.

Lavage is carried out preliminary to the operation, and, about half an hour before, ¼ grain of morphine and 1/150 grain of atropin is given.

[1]Submitted for publication February 22, 1927.

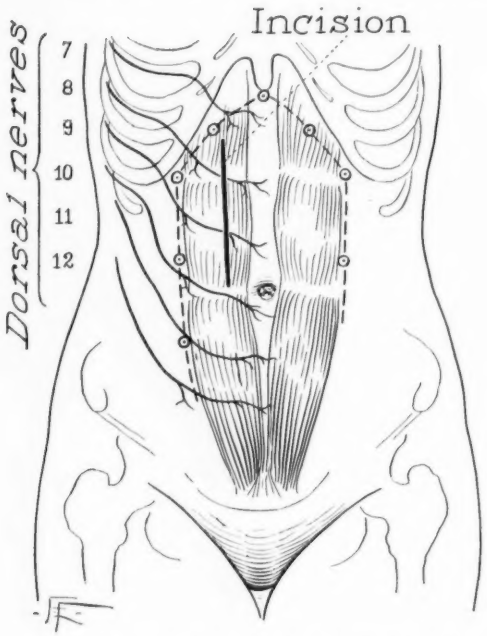


Fig. 1. The broken line extending from the xyphoid to the borders of the recti muscles and following down their margins is the line of infiltration from the skin to the deep fascia and blocks the intercostal nerves as they terminate in the structures of the abdominal wall.

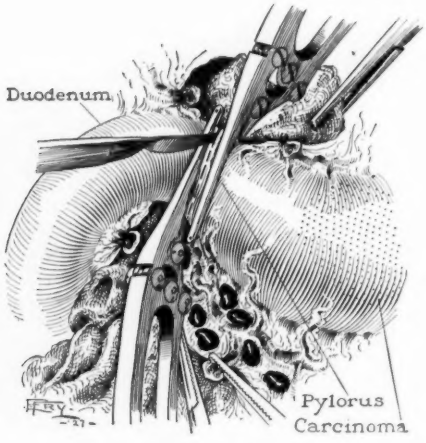


Fig. 4. Division of duodenum.

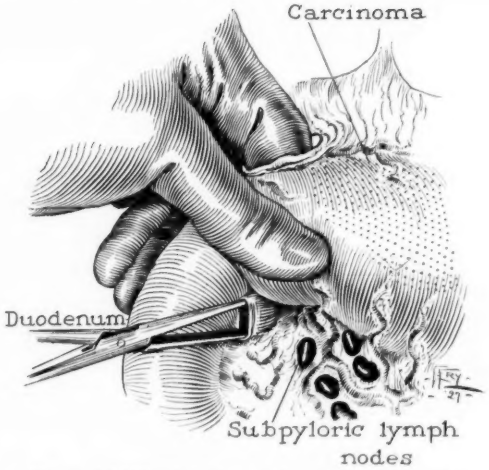


Fig. 2. Mobilization of the pylorus, stomach, and duodenum; selection of a bloodless area on the inferior border of the duodenum to begin the division and ligation of the gastrocolic omentum.

The abdominal wall block is induced over a certain area, as shown in Figure 1. Exploration can then be satisfactorily carried out, and should resection be found possible an ethylene-oxygen-ether combination may be administered. In some respects this is the safest anæsthetic I know of for such cases.

INDICATIONS FOR OPERATION

Exploration should be thorough, particularly of the pelvic peritoneum and liver. Usually examination of the stomach and the adjacent lymph nodes promptly reveals whether resection is advisable. It cannot be too frequently emphasized that fixation of the tumor and extensive enlargement of the lymph nodes do not necessarily mean that the disease is inoperable or incurable, since such conditions may be due to inflammatory processes. In fact some of the most striking cures have been accomplished in this type of case. Although operations for extensive and incurable cancer are to be decried, it is probable that, until better methods of surgery are devised for the cure of cancer, unreasonable attempts to remove the growth will be made in advanced cases simply because removal offers the only possible chance of cure. Resection of the growth is occasionally permissible for palliation only, that is, when it is known that metastasis exists. Sometimes extremely large tumors which, from every point of

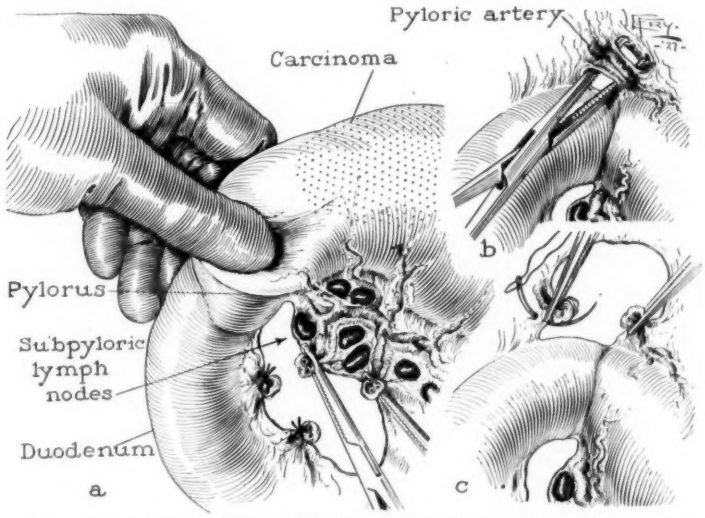


Fig. 3. Space opened in the gastrocolic omentum and division and ligation of the pyloric artery on the superior border of the duodenum.

view, appear to be irremovable are found to be suitable for resection, and the patient is cured. This is particularly true of the colloid type of cancer in which the disease is sharply demarcated. If resection appears to be indicated, the details of the operation are carried out in the following manner.

TECHNIQUE OF OPERATION

If the lesion is not firmly attached posteriorly and the duodenum is not infiltrated by inflammatory products, the resection can well be begun at the pylorus. The finger is introduced through an opening in the gastrohepatic omentum behind the duodenum and pylorus, and by traction the gastrocolic omentum is put on the stretch. An area free from vessels and situated in the gastrocolic omentum at the inferior border of the duodenum about 2 or 3 centimeters from the pylorus is then selected, and forceps guided by the end of the finger introduced through this bloodless area to mark the site of the very lowest point of the

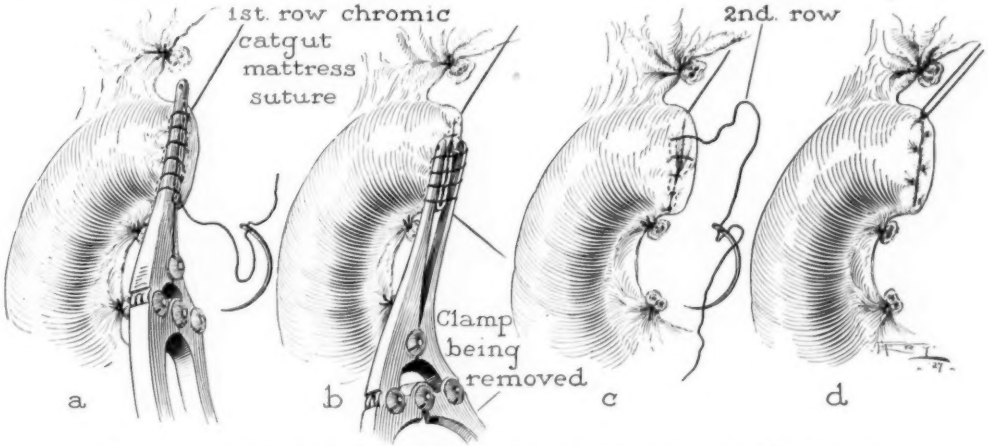


Fig. 5. Closure of the duodenal stump after ligation of the pyloric and gastro-epiploic vessels.

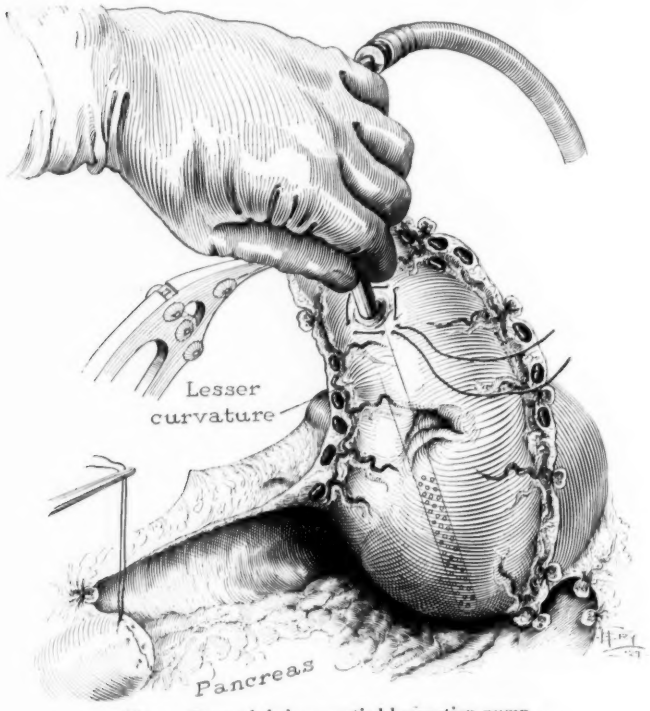


Fig. 7. Stomach being emptied by suction pump.

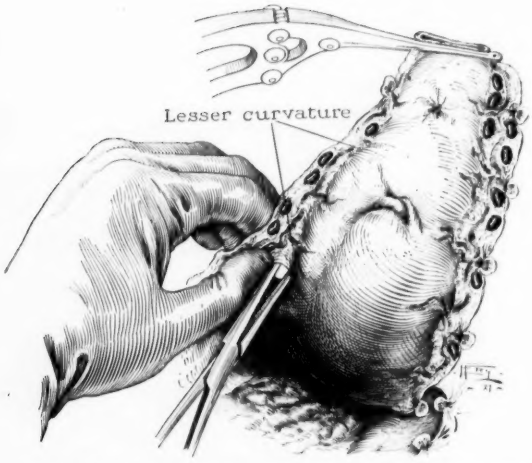


Fig. 8. Making opening in gastrohepatic omentum preparatory to its clamping and division.

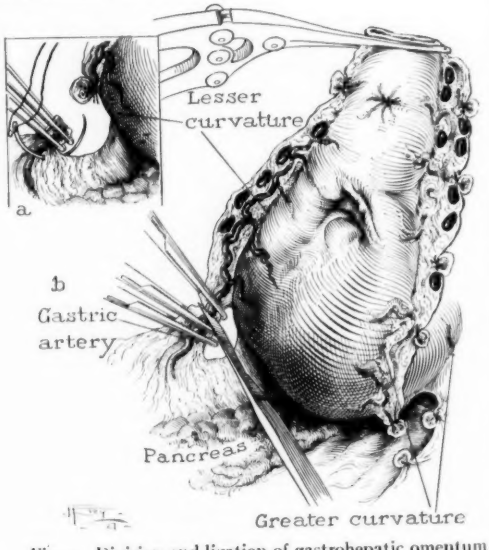


Fig. 9. Division and ligation of gastrohepatic omentum at site of gastric artery.

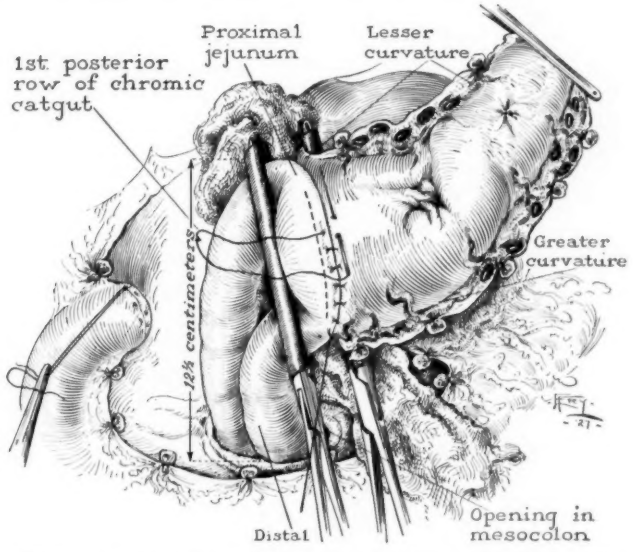


Fig. 10. Arrangement of jejunum and stomach for posterior Pólya anastomosis.

separation of the gastrocolic omentum from the duodenum. The subpyloric group of lymph nodes is then mobilized and the gastrocolic omentum divided on a line such that the entire lymph-node area is included (Figs. 2 and 3). After this portion of the gastrocolic omentum is divided, the gastrohepatic omentum is also divided by putting it on stretch by the finger, a bloodless area being selected on the superior border of the duodenum far enough from the pylorus to remove a reasonable amount of the omental tissues bearing lymph nodes (Fig. 3*b*). The procedures thus far carried out open up sufficient space behind the pylorus and the duodenum to introduce a pack (Fig. 4) and also to permit the application of clamps.

Usually the duodenum can be mobilized so that the clamps can easily be placed on a sufficient stump of the duodenum to insure ready closure. When there are extensive inflammatory processes and infiltration of the disease into the pancreas, there may be difficulty in mobilizing the duodenum and also in placing the clamps, but if proper judgment has been used in attempting resection and sufficient care has been given to the mobilization of the duodenum, the clamps can be so applied that closure is accomplished satisfactorily. After Payr's clamp is applied, the duodenum is divided, the ends cleansed carefully, and the stump of the duodenum closed (Fig. 5) with chromic catgut in a continuous mattress suture, the clamp being included in the loops. After the first row of sutures is placed, the clamp is removed, and the sutures pulled taut. The second row is made like the first and the sutures tied. The end of catgut is left as a marker so that, at the completion of the operation, the closure may be reinforced by a surrounding tag of omentum.

Mobilization of the stomach and its omental attachments is now begun. First a wide strip of the gastrocolic omentum is removed up to a point high enough on the greater curvature to be well away from the limits of the lesion (Fig. 6). At this point it may be extremely advantageous to empty the stomach, particularly if it is markedly ballooned by gas and retained fluids. The suction pump can be introduced through a small opening in the posterior wall, and the opening closed afterward with a purse-string of catgut (Fig. 7). The gastrohepatic omentum is then divided. To insure the most thorough removal of adjacent lymph nodes, it should be divided at as high a point as feasible in the individual case. If firm traction is made on the stomach by the assistant, and the fingers of the surgeon's left hand support the gastrohepatic omentum (Fig. 8) from its anterior aspect, thus

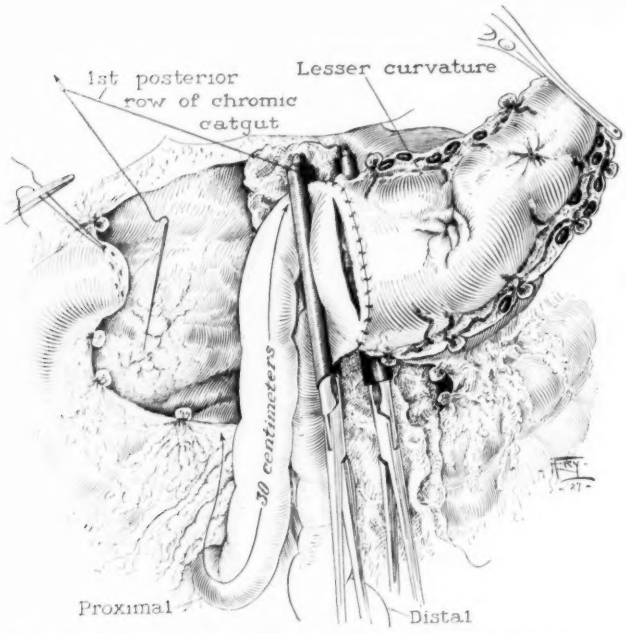


Fig. 11. The relation of jejunum to stomach at the beginning of an antecolic end-to-side anastomosis.

placing it on tension, an area on the lesser curvature, free from vessels, can be selected at a suitably high point, and by blunt dissection with forceps the tip of finger can be carried from the anterior side through this opening and the forceps introduced into it (Fig. 9). Then the forceps are carried through and the entire omental attachment clamped. Two other pairs of forceps are placed above this and the omentum divided above the lower two forceps. This gives a most precise and safe control of the entire gastrohepatic omentum and the stump can be transfixed with a double chromic catgut suture beneath the two pairs of forceps (Fig. 9 *a*). After all the omental tags are divided and ligated, the stomach is again carefully inspected to determine the limits of the tumor and a rubber-covered clamp placed across the stomach far enough from the limits of the growth to make certain that it will not be encroached on when the stomach is divided.

The re-establishment of gastro-intestinal continuity is the next question to be considered. This is governed largely by the extent of the operation. In resections of moderate extent, the posterior transmesocolic end-to-side anastomosis, the method ascribed to Pólya, can be satisfactorily performed with the proximal jejunum applied to the lesser curvature of the stomach and the distal to the greater, the proximal loop being about 12 centimeters long (Fig. 10). If, however, as is more often the case, the resection is more extensive, a method which I described in 1917, that is, end-to-side anastomosis in front of the colon, has distinct advantages. The first loop of the jejunum about 30 centimeters long, is brought up in front of the colon. A section of jejunum corresponding to the size of the opening in the stomach is caught lightly in a rubber-covered clamp (Fig. 11). It is seldom that this section of jejunum is larger than the usual gastro-enterostomy opening. The emptying of the stomach, as previously described, will permit the stomach to contract to a reasonable size, and it is only rarely that one must partially close the end of the stomach before uniting the stomach and jejunum. As a matter of fact, I believe that it is safer to employ the entire end of the stomach in the anastomosis. The first line of chromic catgut sutures unite the jejunum to the stomach, and particular care should be taken to place two or three closely

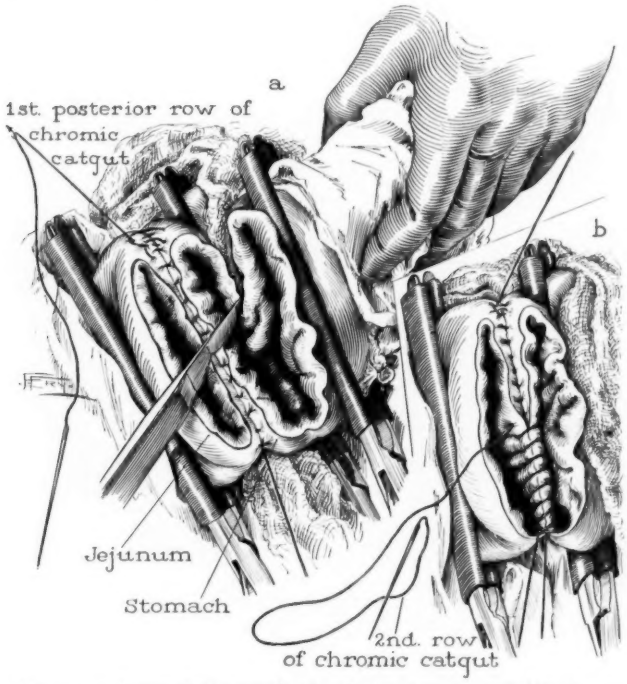


Fig. 12. *a*, Removal of stomach after first posterior suture line is completed. *b*, Beginning of second row posteriorly. All coats included in suture.

applied locking sutures at the lesser curvature. The stomach is then cut away and the mucosa carefully inspected for gross evidence of any remaining disease. The jejunum is opened and a second row of closely placed chromic catgut sutures is applied (Fig. 12). This suture, beginning at the greater curvature, continues to the lesser curvature, and takes in the full thickness of the edges of the jejunum and stomach. After the lesser curvature is turned, the suture includes only the mucosal layer of the stomach and jejunum. When about one-third of the anterior wall is sutured, the rubber-covered clamps are loosened and the posterior suture line is inspected to make certain that all bleeding is controlled, the stomach is emptied of any secretions or blood that it may contain, traction is made on the edges of the stomach and jejunum (Fig. 13), the clamps are closed again, and the first anterior row of sutures is continued to the greater curvature. The second row of continuous chromic catgut sutures is begun at the greater curvature and inverts the exposed and approximated mucosa. It then continues up to the lesser curvature where it is tied to the first posterior suture and cut. The chromic catgut which is used for the first posterior suture line is continued anteriorly as a third row and tied at the greater curvature (Fig. 14).

After completing the end-to-side anastomosis in this manner and making certain that hæmostasis, particularly in all omental tags, is absolute, one approximates the proximal and distal loops of jejunum at a point on a level with the duodenojejunal angle. An entero-anastomosis is made at this point by a two-row suture of chromic catgut (Fig. 15). The opening does not need to be large, since its only purpose is to drain the proximal loop and prevent retention of the contents of this long loop. In carcinoma there is certainly no objection to this entero-anastomosis and it is of considerable advantage. In ulcer there may be theoretical disadvantages enough to outweigh the advantages in diverting alkaline secretions from the stomach. However, there is no direct evidence even in gastric ulcer that such anastomosis interferes with an otherwise good result. The loops of intestine are now arranged

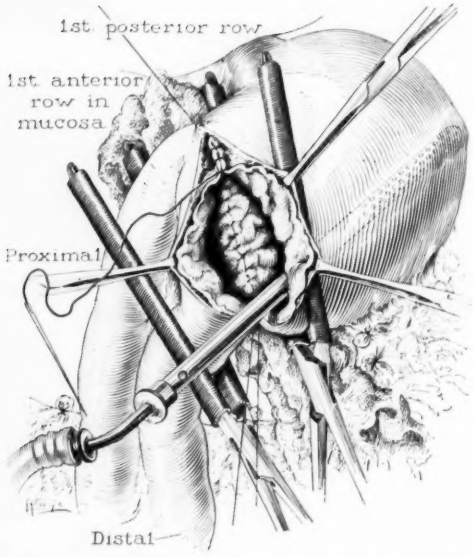


Fig. 13. Loosening clamps after posterior rows have been completed, to empty stomach and inspect posterior suture line.

in the position which they will occupy, that is, to the left of the median line and, if possible, the left portion of the omentum may be arranged over the site of the anastomosis.

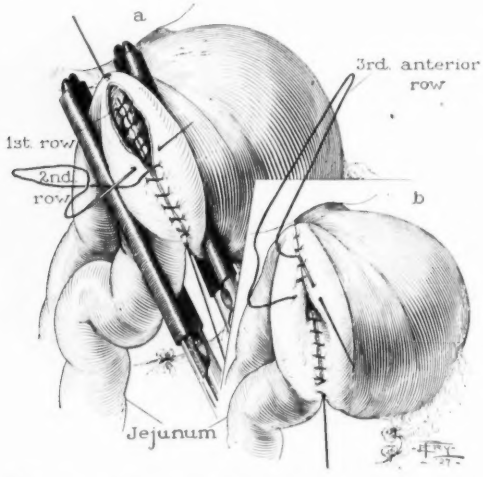


Fig. 14. *a*. Second anterior row (seromuscular) suture. *b*. anterior row (serous suture) continuation of first posterior row.

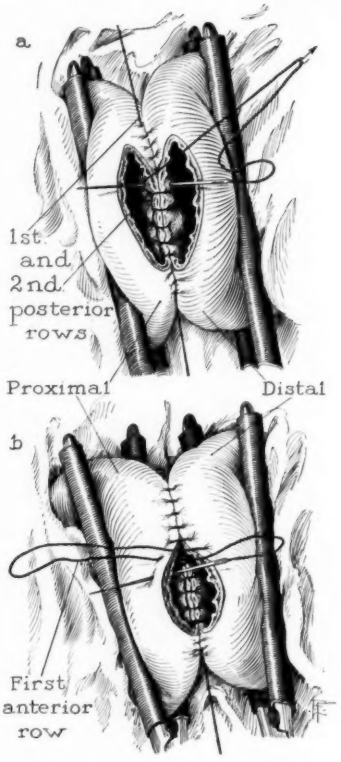


Fig. 15. Entero-anastomosis. *a*. Second posterior suture through all coats. *b*. Anterior suture line.

The operation is completed by re-enforcing the duodenal stump with another pursestring suture of chromic catgut, when necessary, or if the stump has been easily closed, by simply drawing the tags of the gastrocolic and the gastrohepatic omentum over the suture line with the suture placed on the outer wall of the duodenum, so that as the suture is tied the duodenal stump is carried backward into the pocket between the head of the pancreas and the inner wall of the duodenum (Fig. 16). Finally, after the entire field is inspected for any bleeding points in omental tissues and the upper abdomen is washed out with warm sodium chloride solution, the abdomen is closed (Fig. 17).

POSTOPERATIVE CARE

In the postoperative care of patients who have undergone partial gastrectomy, it is most important that the stomach be kept clean and that

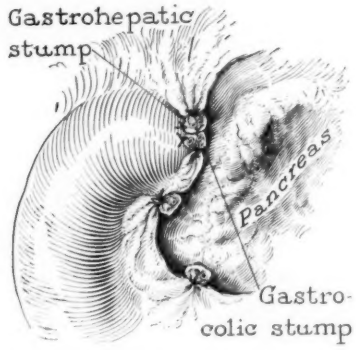


Fig. 16. Stump of duodenum covered by the gastrocolic and gastrohepatic omental top.

retention be avoided. Rarely does retention occur with this type of anastomosis, but patients greatly appreciate the comfort which follows lavage of the stomach. The majority of patients are more comfortable if they are in a semi-sitting position in bed, although this posture should not be made a rule. They should be permitted to assume any position they prefer. Fluids are maintained by proctoclysis; at least 2000 cubic centimeters of plain water should be introduced daily.

The comfort and possibly the safety of the patient are enhanced by withholding fluids by mouth for at least 48 hours after operation; and unless thirst is complained of, which is unusual because adequate amounts of fluid are administered in other ways, fluids by mouth need not be given until the third or fourth day after operation. I have seen no disadvantages in this plan. Morphine is given as needed, but it

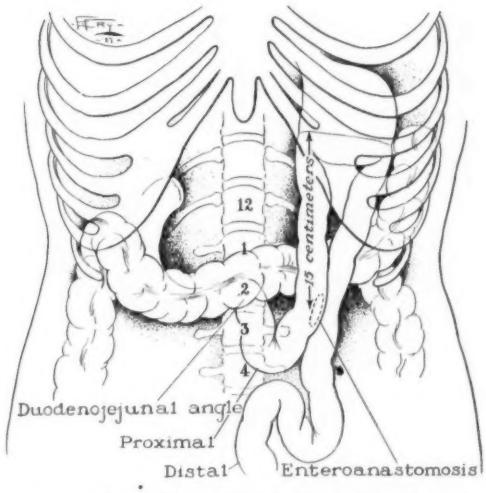


Fig. 17. The relation of parts after the completion of an antecolic end-to-side anastomosis with an entero-anastomosis.

is rarely necessary after the first twenty-four hours and in many cases none is required. The majority of patients are permitted to get up on the eighth, ninth, or tenth day.

MORTALITY

Without cases being selected on the basis of operative risk, the mortality for partial gastrectomy in cancer should be under 10 per cent. During 1926, partial gastrectomy was performed 120 times in the Clinic for malignant disease of the stomach and nine deaths resulted, a mortality of 7.5 per cent.

FROM THE ROYAL BAVARIAN ORTHOPEDIC CLINIC OF MUNICH

THE OPERATIVE SPLINTING OF THE VERTEBRAL COLUMN IN POTT'S DISEASE

By FRITZ LANGE, M.D., Munich, Germany
Professor Ordinarius of Orthopedics, University of Munich, Director of the Royal Bavarian Orthopedic Clinic of Munich

BEFORE 1902 I made repeated attempts to design a type of corset that would arrest the very rapid development of the deformity in Pott's disease. After a number of years of experimentation I came to the conclusion that the corset alone would not solve the problem.

The readiness with which surgically implanted foreign bodies become healed in, suggested to me the feasibility of an operative splinting of the vertebral column.

The first operation of this kind I performed in the year 1902 and reported personally about it at the surgical congress in Washington in the year 1910. For this operation common steel splints were used.

Since that time several surgeons have followed my example or have modified my operation (Albee, Henle, and others). During the period of 1920 to 1924 I have operated on 52 cases and have used exclusively cylindrical splints made of celluloid, from 5 to 10 millimeters in diameter and from 10 to 30 centimeters in length.

PREPARATION OF THE PATIENT

For several days before the operation, the patient receives daily baths and any impurities of the skin are attended to. On the night before the operation, the bowels are evacuated. The patient is shaved just before he receives the anæsthetic. The latter is administered by commencing with ethyl chloride, a little eau de Cologne being added. We then follow this with the usual anæsthesia by the open method. The skin is cleansed with alcohol and painted with tincture of iodine.

TECHNIQUE OF THE OPERATION

I make the skin incision close to and parallel with the line of the spinous processes. The length varies from 10 to 30 centimeters according to the length of the area to be splinted. Fascia and muscles are then divided the full length of the incision and as close as possible on both sides of the spinous processes. With a 2 centimeter bladed sharp raspatory, the muscles are detached to the depth of the vertebral arches.

The most important part of the above procedure is to exercise an even and firm pressure, and to cover with compresses and other dressings all cut parts for the purpose of arresting hæmorrhage. If this is done properly by the assistants, the loss of blood is quite minimal and the tendency to hæmorrhage should cease within 5 minutes.

Ligatures are seldom required. Each of the now exposed spinous processes are perforated at the upper half, and a loop of silk thread (No. 12) is carried through the hole. For this purpose I generally use the Reverdin needle. Through a second hole drilled a little below, or through the interspinous ligaments, the same loop of thread is returned to the other side, leaving thus a U-shape of double thread on the one side and the four open ends on the other. Celluloid splint which has been fitted exactly to the curve of the gibbus is inserted into the U-shaped loop, and another similar splint is placed on the other side of the spinous processes. The latter splint being now grasped between the free ends of the thread with a firm tension is securely tied to the spinous processes with a knot. The splints must be so tightly secured that any movements would appear impossible. They are then carefully covered up with muscles and fascia and sutured in the ordinary way with silk No. 6. Upon this is to follow a deep and superficial suturing of the subcutaneous tissue with silk No. 6 and No. 3 respectively.

The dressing. The patient is placed in the abdominal position, a moderate lordosis being allowed. After the whole back has been padded with cellulose wadding, we place over the splinted region two thick cushions 5 centimeters thick. The cushions are to take the weight of the plaster-of-Paris dressing and to relieve the field of operation from undue pressure. After the padding has been covered with a plaster-of-Paris dressing, extending over a part of the head in cases of dorsocervical gibbosities, a large "window" is finally cut into the plaster over the operative area.

The dangers of the operation. Apart from controlling during the operation the possible hæmor-

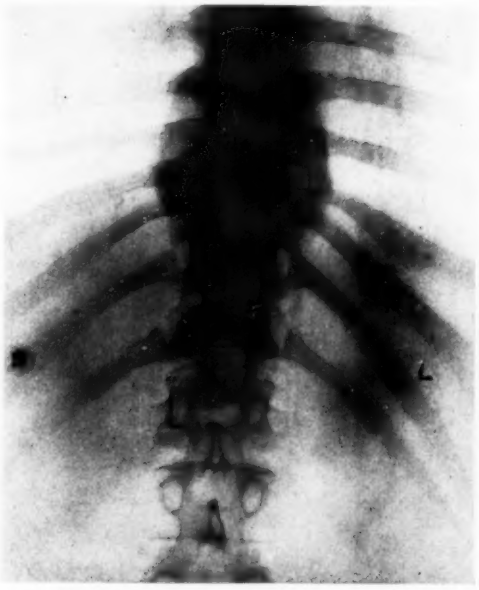


Fig. 1. Roentgenogram made in January, 1926, of case of Pott's disease; on the right, a celluloid splint 15 centimeters long; on the left, one of rust proof steel.

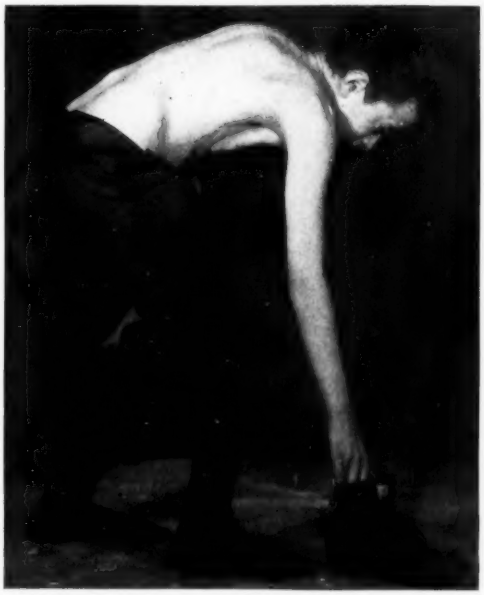


Fig. 2. O. Mayer. Spondylitis of the (1) breast and (2) lumbar vertebræ. Operation in June, 1921; 2 celluloid splints 25 centimeters in length were implanted. This photograph was made 5 years after the operation, and shows how little the motion of the spinal column has been limited.

rhage described above, there is only one thing to be guarded against carefully. When the needle is pushed through the interspinous ligament, the operator has to be careful not to go through the deeper parts of the ligament for fear of getting into the vertebral canal and damaging the cord.

After the operation, the duration of which should not exceed ½ to 1 hour, we have met at times a weakness and a small pulse from patients who have already had a miserable habitus. In such cases we have administered repeated saline infusions through the rectum for 3 or 4 days.

As a rule we dismiss the patient from the hospital after 2 months, after which period ambulatory treatment is given.

I am glad to say that to date the mortality from this operation has been nil. Complications were met with in 5 cases only. In these cases I was compelled to remove the implanted splints. This was due to faulty technique at the experimental stage of the newly introduced operation. In an endeavor to improve the gibbosity I had prepared the splints a little too straight and not quite corresponding with the curve of the hump. The result was that the ends of the splints were slightly springy and therefore endangered the skin. Although this idea proved to be an advantage and an absolute success in 6 cases in which I managed to improve the grade of the gibbosity, it had on the other hand the disadvantage in the 5 cases mentioned of causing the skin to break, thus compelling me to remove the splints. After these unfortunate mishaps, I have made it a practice to fit the splints exactly to the form of the gibbosity, and to be sure even to bend the ends of the splints a little downward. Since I have taken this precaution, none of the patients has had bed sores.

POSTOPERATIVE CARE AND TREATMENT

After the patient has remained in his plaster-of-Paris dressing for 6 weeks, he receives a properly fitted corset and can get up, but he must wear the corset for a period of 2 years. This double support to the vertebral column is desirable, as I have found that at least a year is required for the splints to be surrounded with real firm resistant tissue.

PROGNOSIS

To what extent have we succeeded in checking the progress of the growth? A positive and honest

answer can in my opinion not be given for at least 15 to 20 years after the operation. At present I can judge only the immediate results. I am glad to say that I have experienced only one disappointment with a patient who was suffering from a lumbar gibbosity of Pott's disease. Contrary to instructions the patient had left off his corset 6 months after the operation. That his hump got worse was only to be expected, as splints and silk fixtures could certainly not have acquired, in that short time, tissue of sufficient resistance.

MODIFICATIONS

As to Albee's and Henle's modifications in which the vertebral column is splinted with chips taken from the tibia of the patient, I would like to give my reasons here for preferring my method. It will be readily understood how frail a freshly derived bone chip must be for splinting purposes. A continuous risk during reconvalescence is fracture of the bone splint due to some brisk movement of the patient. This risk demands a very careful and prolonged plaster-of-Paris dressing and a stay in bed of 6 months or longer. On the other hand, splinting with celluloid or steel gives considerable stability of the vertebral column almost at once. Proofs of this are the disappearance of pain immediately after the operation and a general improvement in health. The fact that my patients are allowed to get up after 6 or 8 weeks, I consider another great advantage over Albee's modifications; the patient is able to be outside in the fresh air, a very important factor in the treatment of any tuberculous disease.

CONCLUSION

Since 1924 I have altered my technique by using one splint made of rust proof steel placed on the one side with a celluloid splint on the other.

I started the use of this modification after experiments on animals had proved that the healing-in process of steel was quite as satisfactory as that of celluloid. For fixing the splints to the spinous processes, I now use thin steel wire of the rust proof variety instead of silk. The advantage of steel, which naturally has greater stability than celluloid, is evident. I dare say a 3 to 4 millimeter steel splint would quite favorably compare in stability with a 10 millimeter celluloid splint. Consequently, I expect I shall soon abandon the celluloid splints altogether and employ steel ones only.

A NEW TECHNIQUE FOR PERINEAL PROSTATECTOMY WITH PRESERVATION OF THE EXTERNAL SPHINCTER[1]

By JOHN H. MORRISSEY, M.D., F.A.C.S., New York

From the James B. Brady Foundation of Urology, New York Hospital.

THE preference for suprapubic prostatectomy over perineal methods of removal may be ascribed to two reasons. The first is the technical difficulties of the perineal method; surgeons, unless especially trained in perineal technique, find it very difficult or are unwilling to carry out a procedure of which they feel less sure than suprapubic prostatectomy.

Secondly, incontinence has been an annoying factor and a source of great complaint in the after conduct of the case. This, to many, is sufficient reason for discarding the perineal route for the suprapubic approach. This incontinence usually does not occur immediately after operation; and to be sure, variations in technique may account for a variety of results. Admitting, however, that it is met with, there is opportunity for the improved operative procedure described in this paper.

Incontinence is a relative term and with respect to its occurrence after perineal prostatectomy, reference is made to all degrees from dribbling, extreme urgency, lack of control separate from anal control—to complete incontinence. This latter is seldom met with, but the other conditions are often seen.

The control of the urine depends on the integrity of both the internal and external urethral sphincters. In the development of a prostatic hypertrophy the enlargement may extend into the rectum, or forward around the urethra. In a third type where there is marked bladder intrusion, certain changes take place in the internal sphincter that are of much practical importance. This intrusion of the prostate goes on until the circumference of the sphincter is increased three or four times. Following complete retention and still greater distention the sphincter vesicæ and compressor urethræ muscles have insufficient strength left and yield to the pressure so that the urine overflows more or less continually: the so-called incontinence of retention. It is obvious, therefore, that in an operation for the removal of the prostate in this type of case in which the external sphincter has been severed and destroyed, the internal sphincter is insufficient to give the patient satisfactory urinary control. This internal sphincter encircles the first portion of the urethra and is derived from the deeper muscular layer of the trigone; muscles of the adjacent bladder wall do not enter into its productions. The external vesical sphincter is quite a different structure. It begins around the apex of the prostate and encircles the urethra in the form of bundles of striped muscle. Anteriorly the bundles lie in front of the urethra. Below, the sphincter is combined with the compressor urethræ muscle and may be regarded as a prolonga-

Fig. 1. Showing retractor in place and curved incision carried deeper in center.

[1] Read before the New York Academy of Medicine, Urological Section, April, 1925.

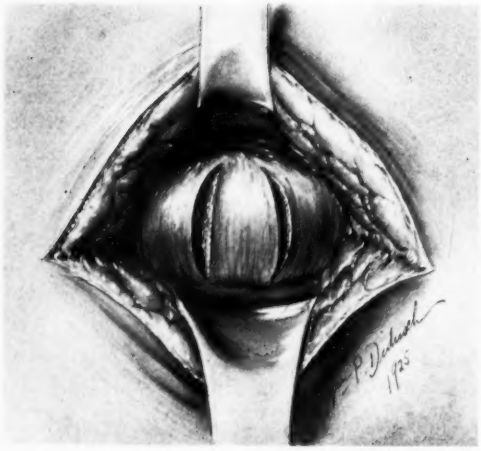


Fig. 2. Exposure of prostate with elliptical incisions into the capsule and substance of the adenoma. These incisions are carried well to the outer sides of the urethra.

Fig. 3. Beginning dissection of the adenoma, external to the urethra, from which it is lifted by means of an elevator.

tion of the muscle. In the region of the triangular ligament, the muscle is reinforced by stout annular bundles of fibres from the compressor urethræ muscle. When this is stimulated to contract either by voluntary or actual involuntary reflex stimulation it contracts around the canal and furthers sphincteric control. It is this contraction at the point where the urethra passes between the two layers of the triangular ligament that impedes the entrance of a sound or instrument into the bladder. At the point at which the prostatic urethra enters the bladder it is surrounded by the internal vesical sphincter, a muscle made up of unstriped fibers.

Fig. 4. Separation of the adenoma externally by the finger after the dissection has been begun with a blunt instrument. The finger can be carried posteriorly to the adenoma and urethra.

Normally, urinary leakage is prevented by the tonic contraction of the muscular apparatus of the membranous and prostatic urethra. When bladder distention occurs, the internal vesical sphincter yields normally and the urine actually enters the posterior part of the prostatic urethra. This causes a desire to urinate and further control depends on the resistance action of the voluntary fibers of the external vesical sphincter and the compressor urethræ. A practical demonstration of the above process is shown in the apparent discrepancy in length of the prostatic urethra when the bladder is full and after it has been emptied. This is due to the fact that the posterior urethra, once the bladder has been filled, actually becomes a part of the bladder. Thus it may be seen that normally the major operation of urinary control and certainly the greater voluntary portion of it depends on the external sphincter. Any operative procedure which tends to destroy the function of this muscle is unwise, and, if the same results can be accomplished otherwise, these means should be utilized.

In the original procedure for perineal prostatectomy described by Young the technique called for introduction of the tractor through an opening

Fig. 5. Sagittal section showing the finger carried as in Figure 4 and the adenoma being separated from the capsule proper.

in the urethra anteriorly to the apex of the prostate. This severed the fibers of the external sphincter. The relative degree of continence following these operations, at least, in those cases in which complete control has been superseded by incontinence, is due to the fact that the scar following the division of these fibers is usually sufficient to give control. However, absorption of this scar eventually takes place and if the internal sphincter is not strong, or if its function in any way has been destroyed or interfered with, then we have the situation of an incomplete in-

Fig. 6. Sagittal section showing the finger carried internal to the adenoma and posteriorly, between the adenoma and the urethra. The sound can be felt in the urethra. If there are firm adhesions or the lateral lobes are very large, it may be necessary to divide through the adenoma at this point and remove it from each side.

ternal sphincter plus a destroyed external sphincter. This is the explanation of the dribbling and incontinence met with in many operations.

Numerous improvements have been suggested in perineal technique with a view to preserving the ejaculatory ducts: these do not cope with incontinence. However, Dillon has described a technique embodying aims similar to those presented herewith and reports good results.

The operation used by me since 1922 has been employed in 84 cases. It leaves both sphincters intact and the results are very satisfactory as regards permanent and satisfactory control.

TECHNIQUE

The perineum is made, as far as possible, parallel with the floor, and the so-called exaggerated lithotomy position is most important. The incision is carried deeper in the center, and the lateral fossæ dissected free by blunt dissection. The central tendon is identified and incised up to the point of allowing the bulb to be retracted and the transversus perinei muscle retracted posteriorly. At this point a special tractor that I have devised is introduced into the urethra and opened. This instrument was suggested by the Geraghty seminal vesical tractor. It has the prostatic curve in it and yet opens in the bladder by means of the mechanism in the handle. The use of this instrument obviates the necessity of cutting into the membranous urethra in order to obtain traction. This is the first important point in the operative procedure.

The recto-urethralis muscle is then dissected free from the surface of the prostate by blunt dissection and the finger inserted into the area lateral to the prostate and the loose attachments of the gland freed up in this manner.

The capsule is then incised with parallel incisions well in the center of each lobe and at a safe distance from the prostatic incision. Enucleation of the lobe is then begun and the tissue is lifted away from the prostatic capsule. This enucleation is carried on until the finger passes posterior to the

adenoma and posteriorly to the urethra into the opposite prostatic lobe. The procedure is then repeated on the opposite side. Following this the removal of the lobe from the prostatic urethra is begun. This is accomplished with considerable difficulty when there has been a marked degree of inflammation. There are usually firm inflammatory adhesions between the urethra and the lobe of adenoma and it is generally impossible to separate these entirely without tearing into the urethra at this point. Injury to the prostatic urethra occurs in almost 75 per cent of the cases. The injury is, however, inconsequential and heals rapidly. In addition, it can be used as an entrance for a catheter to the bladder and the bladder drainage carried out in this manner. If the prostatic urethra is not torn, but accidentally opened, the catheter must be passed from the meatus directly into the bladder. The prostatic capsule is then packed with gauze, the levator ani muscles brought together, and the skin wound closed with silkworm gut sutures. When a marked suburethral enlargement occurs, this obstruction can be removed, generally by sharp dissection.

With 5 exceptions, operation in the 85 cases was done under regional anæsthesia, sacral and parasacral, and the usual aftercare followed. Preliminary care, of course, follows the usual lines, namely: attention to the blood chemical findings and the phenolsulphonephthalein tests. The patients are out of bed sitting up for a short time the third day after operation and are induced to walk about the seventh or eighth day. The results have been most satisfactory. In only 1 case have I had any incontinence whatever, and this patient had a 4+ Wassermann. He presented the somewhat complicated picture of complete continence by night and moderate incontinence during the day. He had already had one operation for removal of a large bladder stone and there was a tendency for stones to reform in the prostatic urethra and prostatic sulcus. However, this patient is rapidly developing control. One patient made the surprising record of leaving the hospital 12 days after operation. He had perfect control and this has existed from the date of discharge. It is better to drain the bladder from the perineal sinus as this spares a certain amount of absorption from the urethra. There is no point in opening the urethra when a rupture has not occurred.

Epididymitis, noted as a frequent complication in patients convalescing after operations on the prostate, was met with in but 3 cases before the patient left the hospital. However, 10 patients developed symptoms in the testicle with swelling and pain in the epididymis after leaving the hospital. In these cases the epididymitis occurred from the third to the fifth week after operation. I am unable to explain the disturbed time relation. The preservation of the posterior and prostatic urethra during the perineal procedure seem, however, of considerable effect in preventing this.

Fig. 7. Removal of one lateral lobe after the opposite side with the posterior commissure has been removed. No preservation of center portion of capsule containing the ejaculatory ducts and other structures in the floor of the urethra.

In perineal operations for carcinoma of the prostate, this method cannot be advised. Lack of control has not seemed to have been a difficulty in such cases. If the urethra is torn and sphincter muscles injured, the carcinoma usually grows at a sufficiently rapid rate to provide a sphincter and and dilatation is often necessary. Perineal procedures in these cases should be as extensive as possible, with a view to removing all obstruction; and not so fine a regard for the preservation of strict anatomical features of bladder control and sexual ability need be observed.

CONCLUSIONS

1. Incontinence is a complication of perineal prostatectomy in a fairly large percentage of cases.
2. This is due to variations and difficulties of technique.
3. Damage to the internal sphincter prior to operation makes preservation of the external sphincter essential.
4. The technique described above is designed to preserve the external sphincter intact.
5. Perfect urinary control may be expected if the technique is followed carefully.

ARTHRODESIS OF THE ANKLE

By GEORGE F. STRAUB, M.D., F.A.C.S., Honolulu, Hawaii
The Clinic

WHEN the muscles of the leg are entirely or almost completely paralyzed, the immediate result is flail ankle or drop-foot, frequently of the cavus variety and generally in slight varus position. The subsequent elongation of the paralyzed muscles and tendons and the stretching of the various joint capsules lead to a condition which at best is highly annoying to the patient and dangerous, because in spite of the utmost care he is constantly in danger of stumbling and falling. The foot and ankle have absolutely no stability. This condition at times affects only the talocrural joint, being here at least generally most apparent, but in many instances extends to the talocalcaneonavicular and Chopart joints. In the latter case, of course, the result is more distressing.

For the treatment of the condition a number of methods have been considered and applied with more or less success. In this connection we shall have to mention (1) redressement with subsequent external fixation, (2) orthopedic apparatus, (3) arthrorrhaphy and tenorrhaphy with or without the insertion of artificial silk ligaments, and (4) arthrodesis.

As to the first method, there can be no doubt that thorough manipulation resulting in considerable traumatization of the joint surfaces and efficient wedging of a broad talus into a narrow intramalleolar space with subsequent prolonged fixation in plaster has in certain instances resulted in solid fibrous and even bony union between the joint surfaces. This, however, is the exception. The rule is recurrence of the drop-foot immediately or later after discarding of the cast. There is also another consideration which makes the procedure appear dangerous and inadvisable. The necessary rough handling of the parts is very liable to lead to fat embolism. Besides, in many cases, especially in old patients, it is impossible to reduce the talus into the intramalleolar space; therefore some type of open operation becomes necessary.

The efficient orthopedic apparatus is expensive, needs constant renewal, is at best a clumsy, weighty appliance, and must be worn by the patient for life. If, therefore, we can offer him something less cumbersome, in the long run less expensive, and, above all, more efficient, it is our duty to do so.

The third procedure recommended by Lange, may be used with certain restrictions. This consists in operation on the tendon, ligamentary, and joint-capsular apparatus, with stabilization of the joint by means of artificial silk ligaments. The chief consideration here must always be the sure prospect of giving the patient a *permanently* stable and serviceable foot without an orthopedic appliance. In very extensive or total paralysis of the leg muscles, however, such a result is well-nigh unattainable by these means and therefore cannot be promised to the patient.

Although I have not had any personal experience except the observation of Lange's results, I must say that of all the methods of attacking the tendon, ligamentary, and capsular apparatus, the artificial silk tendon as applied by that author appears to me the safest method, as far as immediate and permanent results are concerned. Silk is a material which is not subject to the vagaries of the body, absorption, elongation, change of structure, etc.; and provided it is imbedded absolutely sterile and the points of insertion are well chosen, it will offer ideal chances for a good result. Unfortunately the technique does not lend itself to ordinary operating room conditions.

Thus, by exclusion, we arrive at the fourth possibility, arthrodesis. All authors agree that this is perhaps the best method for the establishment of a really serviceable limb. If the operation is properly done, true bony ankylosis of the talocrural and, if necessary, of the talocalcaneonavicular and the articulatio tarsi transversa or Chopart's joint will re-establish to a remarkable degree the lost function of the ankle and leg. Under the conditions mentioned it will guarantee the greatest amount of stability and action. In passing, it is interesting to note that the ingenious inventor of arthrodesis, Albert, as early as 1878 selected a case of paralytic pes equinus for one of the first performances of the procedure. He simply curetted the joint surfaces of the talocrural joint and fixed the foot in right angle position. Subsequently the operation was repeated by him and others with and without indication and with consequently more or less favorable results.

Arthrodesis, "the surgical fixation of a joint or artificial ankylosis," must result in true bony

union of the joint surfaces. This is impossible as long as there is any macroscopically perceptible amount of cartilage left covering the joint surfaces, and as long as any secreting synovial membrane remains. Success is also highly improbable before puberty, as before that age there is not sufficient ossification of the tarsal bones to insure vigorous osteoplastic action. Therefore, most scrupulous removal of all the hyaline cartilage and synovial membrane is the *sine qua non* of success of the operation. The age must be properly chosen. Epiphyseal lines must not be injured by the procedure. Furthermore, it goes without saying that eventual contractures should be corrected before the operation by manipulation, achillotenotomy, division of the plantar fascia, etc. The functional aim must be usefulness of the limb without apparatus of any sort.

When we come to a discussion of the means available for the arthrodesis of the ankle, we have to mention a variety of methods which in the hands of the various authors have given more or less satisfactory results.

Before proceeding with the methods proper for the production of ankylosis of the ankle, I must make a few remarks on astragalectomy as related to the subject under consideration. Whitman originally designed the operation for the relief of pes calcaneovalgus. Up to this date nobody has even attempted to dispute the ingenuity and propriety of the procedure, if it is restricted to the correction of the condition for which it was planned. Here certain mechanical requirements are admirably and positively satisfied. But, when in more recent times we observe that astragalectomy is being hailed as a panacea for all sorts of deformities and, among others, of unstable dangle foot, it is about time to closely scrutinize the results. It is true that astragalectomy produces stability and at times preserves the motility of the ankle. But, why preserve a movable ankle if there are no muscles to move it? Is not successful arthrodesis sufficient when the *forefoot* has a certain amount of motility and resiliency left? Astragalectomy has always appeared to me to be a mutilating operation at best, resulting in a definite amount of shortening of the extremity and a disfigurement of the foot —in other words, a poor cosmetic result. This of course serves a very definite purpose, if the operation is done with the indication originally laid down by its author. In all other cases observed by me the gain, as compared with the results of other procedures, is out of all proportion to the sacrifice in bone and appearance. Many patients with bad postoperative cosmetic result and limping gait bear witness to an astragalectomy based on lack of consideration for proper mechanical requirements. Complete paralytic equinovarus, to my mind, cannot be considered together with the subject of astragalectomy.

The proper methods for arthrodesis may be divided into:

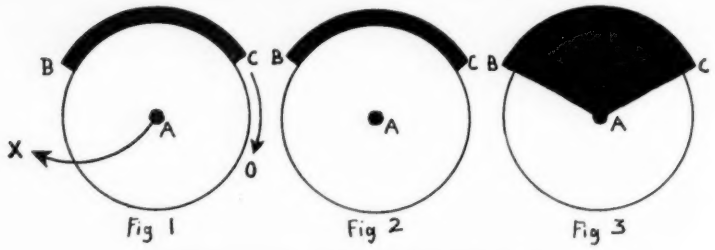
1. Methods in which the attack is on the joint surfaces only.

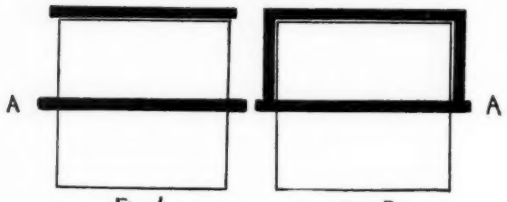
2. Those which add to this reinforcement (a) by fasciodesis or tenodesis or both, and (b) by pedunculated periosteal bone flaps.

3. Methods employing free bone grafts (autogenous and heterogenous) or foreign material (nails, ivory pegs , etc.)

In the methods under heading 1 the approach to the operative field is similar to that used for erasion or resection of the ankle joints. Kocher's lateral incision is preferable for this purpose. Lauenstein (2) Koenig, Albanese, Ochsner (12), and others, have devised modifications of this method to suit individual conditions. But Kocher's method on the whole gives very satisfactory access to the operative area. The joint is opened and by forcing the foot into strong varus position the talus is gradually exposed. After thorough removal of all cartilage and synovial membrane from the talus itself, the lower end of the tibia and fibula, and the inside of the malleoli, the bones may be put into intimate apposition and the wound closed. The result is fibrous or even possible bony ankylosis of the talocrural joint. If it should be desirable to treat the adjoining joints in the same manner, the Kocher incision will in most cases give fairly good access. Steindler (15) in a recent article describes a modification of this type of operation which he has used in a considerable number of cases with good results. It consists of a fusion of all the joints of the ankle with the exception of the calcaneocuboid articulation.

If, on the other hand, any of the methods mentioned under heading 2 are to be employed, fasciodesis (Vulpius), tenodesis, or the formation of periosteal bone flaps may be immediately added to the procedure just mentioned. Here, as a rule, enlargement of the initial incision or the addition of other incisions will in most cases become necessary. Klapp and Vulpius regularly supplement arthrodesis by tenodesis and fasciodesis. Hoffa (10) advised the addition of a pedunculated periosteal bone flap with the base on the lower posterior end of the tibia, which he turned down with the result of forming a bridge to the upper surface of the calcaneus. Cramer





(3) used a periosteal bone flap on the anterior surface of the tibia, thus bridging the talocrural joint in front. In addition he made extensive use of tenodesis and fasciodesis.

The two modifications mentioned last lead us to the third class of methods in which free bone grafts or foreign materials are employed. Lexer (8, 9) since 1906 has practiced ankylosis of the ankle by way of the bone doweling method. He took the material for this purpose from the fibula of the same patient, but also from freshly amputated limbs and macerated bone from human cadavers. The bone dowel is driven from an incision on the sole of the foot through the calcaneus upward via the joint into the lower end of the tibia. As was to be expected, the material in course of time was absorbed, as far as it was exposed within the joint, and the immediate ankylosis which, to my mind, was chiefly due to the traumatic arthritis caused by the penetration of the foreign body, gradually disappeared. The same thing holds good for the doweling of the joint by Bade's method. The operation known as Wrede's, while using the talus as a free bone transplant, is in fact nothing but an arthrodesis of all the joints surrounding that bone with very thorough removal of the joint lining structures. Kosinski (6) lately has advised the application of a rib transplant.

As to the results of arthrodesis of the ankle joint, Vulpius (17) is author of the statement that in about 50 to 60 per cent of the cases the achievement is bony ankylosis, that in another 20 to 25 per cent fibrous union is obtained, and that in the rest there is more or less complete failure. These figures correspond fairly well with those given earlier by Karasiewicz. The fact that these statements are repeated over and over in the literature in articles and textbooks, proves that the experience of other authors coincides with that of Vulpius and that therefore the figures laid down represent a fair evaluation of the final result of the procedure under consideration.

An analysis of the results shows that there are two factors which are chiefly responsible for success: first, the painstaking removal of cartilage and synovial membrane; and second, the intimate apposition of the vivified surfaces. The first point has been mentioned before and also has been emphasized in an earlier article by the author (16) on arthrodesis of the shoulder joint. The second point is based on the simple physiological principle that close apposition makes for rapid vascularization and reconstruction of the tissues concerned in the process of wound healing. The second factor, of course, depends not only upon properly performed arthrodesis, but also upon immobilization of the raw joint surfaces by reefing of the tendons and fascias and, last but not least, on the careful application of the first plaster cast and sufficiently prolonged postoperative immobilization.

The point last mentioned of intimate approximation has for some time past occupied the minds of some surgeons and has taken the form of the problem: By what means can the loss of

Fig. 6. Showing the incision to be made with the ankle joint in the position of extreme extension.

substance entailed by thorough removal of cartilage from the malleolar surfaces of the ankle joint be compensated and thus wabbling or play of the talus within the so-called malleolar fork be prevented? Offhand there are two ways of accomplishing this aim, namely, by narrowing the intramalleolar space or increasing the width of the talus. Wittek (21), Farrabeuf and Goldthwait followed the first route, the former by removing a small slice of bone from the adjacent surfaces of the tibia and fibula at the spatium interosseum, the two others by suggesting osteotomy of the malleoli or the fibula above the joint. Starz thought that longitudinal splitting of the talus would accomplish the same result. Vulpius (19) in his remarks on this point suggests the interposition of cartilage as the logical means of holding the two pieces of talus permanently apart.

Now, to my mind, cartilage is a material not well suited for this purpose. First of all, from a purely mechanical standpoint, it is more or less elastic and is not available in the thickness generally needed to fill the gap. Second, if we consider it physiologically and leave the cartilaginous epiphyseal line as not available and not suitable for our purpose, cartilage is not a material which has great regenerative and healing power. Healing generally proceeds with the formation of connective tissue, and the possibility of bone formation is very small indeed. This is a very important point. Third and last, it is an accepted principle in the field of technique of transplantation that autogenous and homogenous tissues are best suited for the repair of defects: epidermis to epidermis, mucosa to mucosa, tendon to tendon, and in our case, if anything, bone to bone.

In this connection, there is still another important factor of a primarily mechanical nature.

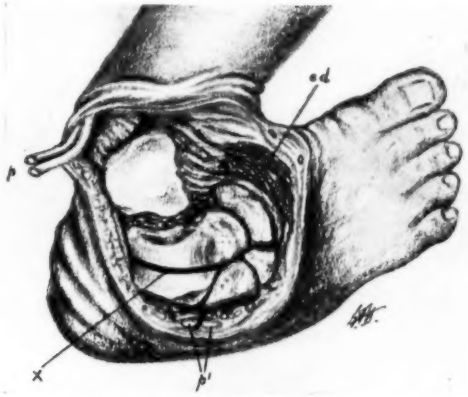


Fig. 7. Showing exposure gained by complete division of skin, fascia, vessels, nerves, muscles, tendons of the peronæus longus and brevis, ligaments, and joint capsule. *pp'*, cut tendons of peronæi; *cd*, extensor digitorum brevis; *x*, line of division of the talus. Foot in extreme inversion and adduction.

For illustration of the mechanical conditions applying to the case under consideration I present five schematic sketches (Figs. 1 to 5). In 1, 2, and 3 the circle represents the talus, A the axis of rotation and B-C the superior contact surface of the talocrural joint. In 1 the axis A is assumed to be freely movable. One can easily see that if a rotating force is applied in the direction of O, B-C will simply roll off the contact surface in the direction of X. If we assume, however, as in Figure 2, that the axis A is fixed, then the rolling off cannot occur; B-C will act as a friction surface with brake effect. Figure 3 shows the actual condition applying in our case, the shaded

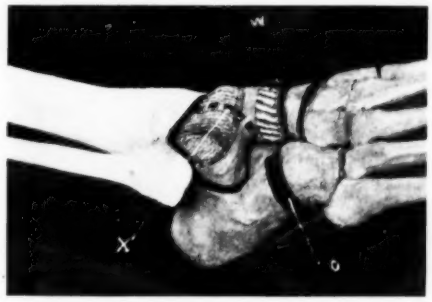


Fig. 8. The black lines indicate the joints denuded of cartilage and synovial membrane. The dotted line, *x*, indicates the plane in which the talus is to be divided. The striated area, *w*, shows the bone disk removed for implantation into *x*. At *o* the joint surfaces are removed a little more thoroughly.

Fig. 9 (left). Roentgenogram made 3 months after operation showing bone graft in talus.

Fig. 10. Roentgenogram made 3 months after operation; lateral view.

area ABC representing the inner surface of the malleoli. Here, in addition to the conditions shown in Figure 2, ABC illustrates the great increase in contact surface. Figures 4 and 5 are cross sections of 2 and 3 respectively and also show the considerable increase in contact surface effected by close apposition of both malleoli.

Bearing all the foregoing considerations in mind I have elaborated and in a number of cases successfully applied a method of arthrodesis of the ankle joint which in my opinion is as sure of a good result as any surgical method can be, and which, in addition, is not difficult of performance, although the technique must be carefully and painstakingly followed.

The mode of procedure is as follows: An Esmarch bandage is applied at the thigh. The ankle and foot are in position of extension. The incision (Fig. 6) starts over the lateral aspect of the fibula between the peronæus brevis and the extensor digitorum longus about 8 centimeters above the tip of the malleolus externus. From there it proceeds slightly backward to a point about 1 centimeter behind the malleolus, then commences to curve forward to a point halfway between the tip of the malleolus and the tuberositas ossis metatarsalis V, and finally continues in a gentle curve across the dorsum of the foot, ending at a point a little beyond the highest prominence of the instep which corresponds to about the midpoint of the articulation of the first and second cuneiform process and the second metatarsal. The incision penetrates through the skin with its vessels and nerves, severing the nervi cutaneus dorsalis pedis lateralis, intermedius, and a branch of the nervi cutaneus medialis. This results generally in a temporary numbness of the third, fourth, and fifth toe. The skin flap is carefully dissected back leaving exposed the thin fascia covering the tendon sheaths and the fascial reinforcement. The division of the retinaculum peronæorum superius, inferius, and the latter's continuation, the ligamentum cruciatum, frees the tendons of the peronæus longus and brevis. These tendons are generally best divided at this stage of the operation. The tendon of the peronæus tertius is cut next. The tendons of the extensor digitorum longus and extensor hallucis longus are with the ligamentum cruciatum dissected off and retracted toward the

Fig. 11.

Fig. 12.

Fig. 13.

Fig. 14.

Fig. 11. Roentgenogram made 4 months after operation.

Fig. 12. Roentgenogram made 8 months after operation; graft still visible; osteoplastic fusion of joint distinctly appearing especially on malleoli.

Fig. 13. Roentgenogram made 20 months after operation; the outlines of the bone graft are shown to be disappearing.

Fig. 14. Roentgenogram made 25 months after operation; fusion complete.

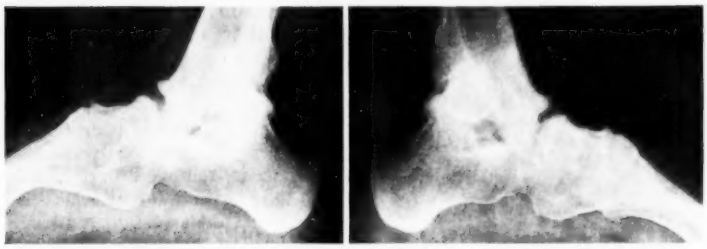


Fig. 15. Roentgenogram made 25 months after operation; fibulotibial and tibiofibular views.

median line. It is well to carry the separation of these tendons well above and below the line of the skin incision.

The next step is the dissection of the extensor hallucis brevis and the extensor digitorum brevis off the calcaneus in the neighborhood of the sinus tarsi. This dissection is also carried well toward the toes. Here it is necessary to be mindful of the arteria tibialis anterior and its branch, the arteria arcuata, which are not to be divided, if it is possible to avoid them.

These preliminary steps expose (Fig. 7) the articulatio talocruralis, talocalcanea, talonavicularis, calcaneocuboidea, and cuneonavicularis. These joints are attacked in the sequence mentioned. Under increasing hyperextension and hyperinversion of the area, beginning with the tarsomalleolar ligaments, the joints are opened. All cartilage and synovial membrane are removed from the joint surfaces and recesses with chisel, rongeur, curette, and scissors as painstakingly as possible. The spongiosa of all the surfaces should be plainly evident, wherever bony union is desired. The inner surface of the malleoli and the corresponding aspects of the talus deserve special attention in this respect. After this step of the operation has been completed, the talus holds its connection with the rest of the tarsus only by means of the structures inserting on its medial, posterior, and posterolateral surfaces and the navicular by its attachments on the caudal aspect. These attachments are by no means to be disturbed.

The previous step has decreased the mediolateral diameter of the talus to such a degree that intimate apposition within the malleolar fork has become illusory. In order to re-establish this relationship, the bone is split with a chisel in the midsagittal plane (Fig. 8) into two distinct halves with a gap between, each half being attached to the neighboring bones by the structures mentioned above. Now the width of the cleft is estimated and a disk of bone is cut from the anterior pole of the caput tali. This disk is of

Figs. 16, 17, and 18. Showing result on weight-bearing.

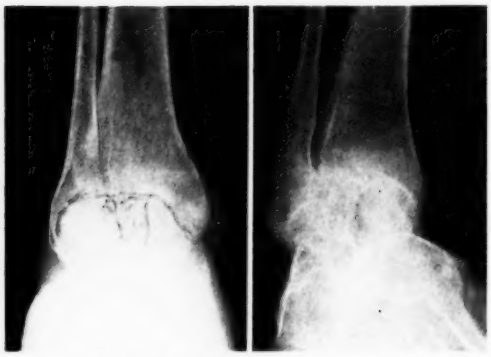


Fig. 19 (left). Roentgenogram taken 2 months after operation; bone graft well outlined.

Fig. 20. Roentgenogram taken 10 months after operation; excellent fusion; outline of graft just disappearing.

sufficient thickness to fill snugly the gap and to assure close apposition between the talus and the former joint surfaces of the malleoli. This completes the most essential part of the operation.

The shortening of the talus resulting from removal of the graft is inconsequential, as far as appearance or function of the tarsus is concerned. To prevent excessive adduction of the forefoot it may be advisable to go a little further in removing the joint surfaces of the calcaneocuboid joint.

Now follows the closure of the various layers of the wound. A few sutures of thin catgut inserted into the ligaments assure preliminary apposition of the bones. It has already been mentioned that occasionally achillotenotomy has to be done to bring the foot into the proper position. This, of course, is done before the operation, proper is begun. I have also mentioned that in arthrodesis I rely chiefly on the proper bony union, and that I see in the fixation by surrounding structures not much more than a temporary help which holds the joint in the proper position until my aim, bony union, has been achieved. Therefore, while not discarding fasciodesis and tenodesis, I make only such use of it as I consider suitable to the occasion. In the case under consideration, for instance, I simply reef the tendon of the tibialis anterior and reunite the peronæus tendons at the proper tension. In order not to cause later deformity of the toes the best judgment must be used in the reefing of the long exterior digitorum and extensor hallucis and the suturing into place of the short extensors. This is especially true when traces of action are left in any of the muscles of the leg, as happens frequently.

After all these structures are sutured into place with as little and as fine suturing material as possible, and after complete hæmostasis is secured, the skin wound is closed with fine catgut and a light plaster cast is applied. This is placed in the desired position and reaches from the tuberositas tibiæ to the toes. The Esmarch bandage is removed and the leg kept in an elevated position for at least 24 hours to minimize subsequent oozing from the bones.

Regarding the position in which the ankylosis is to be effected, most authors favor slight plantar flexion. Steindler in the article mentioned advises ¾ to 1 inch plantar flexion. Jones (5), however, basing his opinion on the follow up of numerous war injuries is of the opinion that a few degrees of more acute dorsiflexion than right angle enables the patient to walk with a minimum of strain on the forepart of the foot. I believe that there is no such thing as a standard position and that each case has to be judged on its own requirements. The chief determining factor is the kind of footwear to which the patient is used. Low heels require a position near right angle, high heels a few more degrees of plantar flexion, while for walking with bare feet the observation of Jones may justify a small degree of dorsiflexion. As a rule, I put the foot in slight varus position.

The first plaster cast remains in place for 8 weeks and is then replaced by a very light walking cast, which remains in place for another 8 weeks. Slight attempts at walking, of course with crutches, and weight bearing 2 months after the operation, I believe is a distinct advantage in so far as it hastens consolidation and ankylosis.

It hardly needs mention that the type of operation described should not be performed before adolescence, when the ossification centers will have developed into sufficient size to be of value for a bone graft operation. This principle holds good even more for the author's procedure than for a simple arthrodesis which according to Lorenz (10) should not be done before adolescence, according to Vulpius (18) not before the eighth to tenth year; and is absolutely untrustworthy before the sixth year, according to Albee's (1) opinion.

In explanation of the roentgenograms and photographs appearing in this article I shall quote short histories of 2 cases:

Case 1. J. L. B., female, 31, married, at the age of 9 months had poliomyelitis anterior resulting in paralysis of the left arm and leg. For 2 years the patient was absolutely disabled. The paralysis gradually subsided with the exception of all the muscles moving the left ankle and

Figs. 21, 22, and 23. Showing result on weight bearing.

foot. Only the extensor hallucis brevis showed a trace of activity. The result was complete pes equinovarus and flail ankle. The motion in the knee and hip was good. There was a fair amount of contracture of the gastrocnemius and soleus. The patient's chief complaint was inability to walk comfortably and frequent tripping which was especially dangerous, as she was rather corpulent. Stabilization of the ankle joint was advised.

The operation described was done on January 8, 1924, with arthrodesis of the following joints: talocrural, talonavicular, talocalcaneal, cuneonavicular, and calcaneocuboid. A bone graft was placed in the split talus and achillotenotomy done. A plaster cast was applied in a position slightly larger than right angle. February 16, 1924, the plaster cast was removed, and on March 8 a light plaster cast was applied and the patient allowed to walk on crutches. On April 8, a roentgenogram was made and the cast changed. May 5 the cast was removed and walking with canes allowed. September 10 the appearance and function were good. September 25, 1925, function was excellent, the patient walking without the slightest discomfort. January 21, 1926, the X-rays showed perfect consolidation; and on March 1, 1926, good results. (Figs. 9 to 18 inclusive.)

Case 2. J. H. M., female, married, at the time of her first pregnancy in 1914 had poliomyelitis anterior with the immediate result of partial paralysis involving the entire right side from the neck down. This gradually receded and left her with only about 10 per cent function of the tibialis anterior, 30 per cent function of the extensors and flexors of the thigh, the adductors of the thigh being fairly normal and the gluteus maximus and medius entirely paralyzed. The entire leg musculature with the exception of the tibialis, already mentioned, was paralyzed. The extensor hallucis brevis showed a slight trace of activity. The patient complained chiefly of considerable interference with her ability to walk and constant stumbling and falling. Immediate stabilization of the ankle was advised and a later sacrospinalis plastic operation according to the method of Lange.

On October 15, 1925, the author's operation was done, comprising arthrodesis of the talocrural, talocalcaneal, talonavicular, cuneonavicular, and calcaneocuboid joints. A bone disk from the head of the talus was implanted into the split talus.

On November 28, 1925, the cast was changed; again on December 15 it was changed, and the patient allowed to walk with crutches. February 3, 1926, the cast was discarded, and the patient encouraged to walk with canes only. March 16 the patient was walking without any support. April 27 the result was excellent. August 26 the patient was making such good progress in walking that she thought of having the second operation postponed indefinitely (Figs. 19 to 23).

In conclusion, I wish to say that a properly executed arthrodesis of the ankle joint is a very satisfactory operation from every point of view. I agree fully with Vulpius (17), when he says that in case of failure, the operative technique is to be blamed and that it must be our endeavor to find modifications of procedure which exclude such failure. I am convinced from my experience that the principle of intimate apposition of the talus and the malleolar fork is sound from a mechanical, anatomical, and physiological standpoint and, that, if the principle is applied to any operative procedure aiming at the production of ankylosis of the ankle joint, it will give greater stability and better fusion than any other method.

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TRAUMATIC RUPTURE OF THE DIAPHRAGM[1]

REPORT OF A CASE WITH RECOVERY FOLLOWING OPERATION

BY WILLIAM E. SHACKLETON, M.D., KALAMAZOO, MICHIGAN

THE number of cases of rupture of the diaphragm with herniation of abdominal viscera into the thoracic cavity which have been cured by surgical intervention is so small as to justify the report of an additional case.

The spectacular case reported serves to call our attention to a surgical condition described by Ambroise Paré in 1610 (1). He reported 2 cases of traumatic diaphragmatic hernia as did Fabricius Hildamus in 1646 (2); while the first congenital case was reported by Riverius Lazars in 1689 (3).

Although the possibility of rupture of the diaphragm has been known for centuries, the condition is seldom recognized. Modern textbooks dismiss the subject with a brief paragraph acknowledging its existence. Even the modern surgical diagnosis of De Quervain (5) states that "diaphragmatic hernia is seldom suspected before operation unless previous injury has suggested its possibility." Binnie, in 1914, could find only 2 cases cured by radical operation.

The mortality is high. However, with the aid of modern radiological studies made along the lines laid down by J. M. Woodburn Morison (4), more favorable results should be obtained. The condition can now be recognized before cases come to autopsy or operation in the non-traumatic as well as in the traumatic cases.

There are many classifications of diaphragmatic hernia; a workable one by Richards (7) may be cited.

1. True hernia (having a hernial sac):
   a. Congenital
   b. Acquired
2. False hernia (without hernial sac):
   a. Congenital
   b. Acquired
3. Eventration of the diaphragm

There are 4 types of hernia: those in which herniation occurs through (1) the space of Morgagni, (2) the dome, or (3) the œsophageal opening, and (4) those in which herniation is due to the absence of part of the diaphragm. Hume (6) in reporting 35 cases found the distribution of cases, 1, 18, 12, and 4 for the 4 types in the order named. The hernia is found on the left side six times as frequently as it is found on the right.

Healy (8) states that the aortic opening has never been known to contain a hernia. Therefore the œsophageal opening is the only muscular opening amenable to dilatation. In 53 cases, all of the œsophageal opening, the hernia was usually behind the œsophagus, and varied in size from an English walnut to a large grapefruit. In 1 case two-thirds of the stomach had passed through the opening.

The symptoms present a wide range of variations. In cases of eventration of the diaphragm or absence of part of the diaphragm there may be an entire absence of clinical symptoms or a vague indefinite history of indigestion. Other cases give a history of epigastric discomfort.

[1]Read by invitation before the Kent County Medical Society, Grand Rapids, Michigan, April 14, 1926.

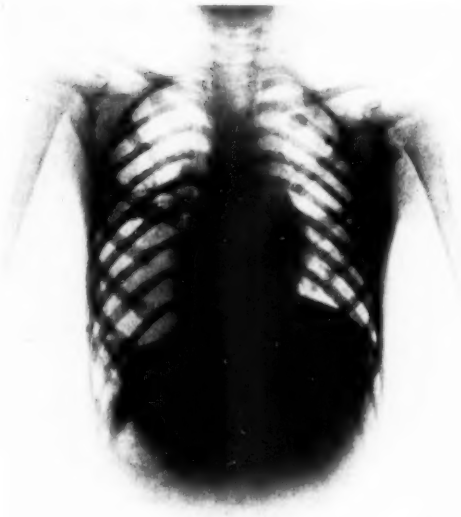

Fig. 1. Prone position. The diaphragm line on the left side cannot be made out. In the lower part of the left lung area there is an area of decreased density. Above this is a clear space occupied by the gas-filled stomach in which lung markings are absent. The stomach wall may be seen at the level of the fourth rib in front and the seventh and eighth ribs behind. The heart is displaced to the right.

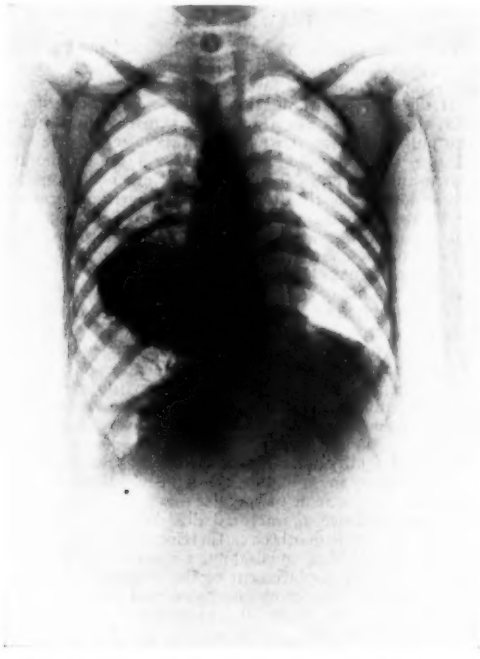

Fig. 2. Prone position. This film was made after the ingestion of the barium meal. Observe the barium in the dependent portion of the stomach. There is a large amount of gas in the herniated portion of the stomach lying above the barium.

substernal pain, pain radiating to the back or left shoulder, gastric symptoms at night, and at times difficulty in swallowing with regurgitation. Many of these patients are not able to lie on their backs after a meal. A number of cases have been reported in which operation has been done for supposed gastric ulcer, without an ulcer being present. Simulation of gall-bladder symptoms is not unusual. With a history of previous injury, especially if there are wounds near the diaphragm, hernia should be suspected. However, in the majority of cases we must look to the radiologist for assistance.

PROGNOSIS

Hedblom (9), in September 26, 1925, reported all recorded cases which had been operated upon: 19 were from the Mayo Clinic with 15 recoveries; 359 were from the literature—a total number of 378 cases with 251 or 66.4 per cent recoveries. Strangulation occurred in 33⅓ per cent of this number; 126 cases showed acute obstruction resulting in a mortality of 53.1 per cent; 252 cases showed no obstruction, with 59 deaths or a mortality of 23.4 per cent. The operative mortality from cases operated upon by the abdominal route was 42.9 per cent, the transpleural route 19.8 per cent, the combined route 26 per cent. Two-thirds of the cases were traumatic in origin and 90 per cent showed no sac.

The mortality is high, but with improved methods and early diagnosis a more favorable outlook may be anticipated.

TREATMENT

As in other types of hernia surgery undoubtedly offers the only means of cure. In all cases of strangulation or incarceration, operation should be done at once. In other cases operation should be performed if symptoms are serious enough to cause disability.

The transpleural route offers more favorable results if the diagnosis is positive and the operative intervention is not done as an exploratory measure.

CASE REPORT

V. C., male, age 9, while wrestling, experienced sudden severe pain in the left upper side of the abdomen. Dyspnœa and symptoms of shock rapidly ensued.

At the time of examination 2 hours after the onset of pain, the face was ashen gray, the skin cold and moist. The pulse rate was 160 and respiration jerky. He was lying on his right side with the knees flexed on the abdomen and the entire body flexed as much as possible. It was impossible to alter this position without greatly increasing the pain. Examination therefore was difficult. The heart was displaced to the right of the sternum. The left side of the chest below the third interspace and back was hyper-resonant and breath sounds were absent. There was no bubbling or gurgling on auscultation over the left chest. Examination of the right side of the chest was negative except for the cardiac displacement. There was tenderness and slight rigidity of the left upper quadrant of the abdomen, but no dullness in the flanks.

The diagnosis seemed to rest between rupture of the diaphragm and acute pneumothorax. There was a possibility of other complications such as rupture of the spleen or other abdominal viscus, but the absence of diffuse abdominal rigidity and dullness in the flanks rendered such a serious injury improbable. Tenderness in the upper left abdomen with extreme pain under the costal margin without gross evidence of fractured ribs did not fit into the picture of a pneumothroax, therefore, in spite of the absence of splashing or gurgling, a diagnosis of ruptured diaphragm with displacement of the stomach was made.

The patient was given morphine and removed to a hospital for X-ray study; it was proposed to operate if the diagnosis could be confirmed.

Radiographic examination was made by Drs. Crane and Jackson. The patient was first observed under the fluoroscope. The heart shadow was much displaced to the right. There was an area of markedly decreased density in the areas ordinarily occupied by the left lung.

Stereoscopic films were made with the patient in the supine position. They showed a shadow in the lower left chest, occupying the area from the level of the third rib in front and the sixth rib behind down to the diaphragm. The line of the diaphragm could not be seen. The edge of what appeared to be an air-containing viscus could be followed along the chest wall down to the normal point for attachment of the diaphragm.

A barium meal was given and stereoscopic films were made with the patient in the supine position. They showed the stomach within the chest cavity, the barium having settled into the posterior portion. The barium could not be made to pass on through to the pyloric end of the stomach.

Films were made with the patient in various positions in an effort to fill with barium the entire gas-containing area of the viscus and the pyloric end of the stomach. These films showed that the stomach, to a large extent, lay in the chest cavity and that the pyloric end of the stomach was shut off from communication with the herniated portion.

The X-ray diagnosis was a diaphragmatic hernia of a large portion of the stomach.

Under nitrous oxide and oxygen anæsthesia, with the patient in a semi-upright position, 5 inches of the eighth and ninth ribs were resected beginning at the posterior angle and passing forward. When the pleural cavity was opened, omentun protruded from the incision, and when the incision was lengthened, the spleen and colon and then the stomach appeared—all in the pleural cavity.

The abdominal organs entered the left chest by way of a rent which began at the posterior angle of the tenth rib and passed forward along the chest wall for a distance of 3 inches. It seemed to be a separation of the diaphragm from the chest wall without much injury to the muscles, although torn fibers could be observed at the anterior ends.

Some difficulty was experienced in replacing the organs in the abdomen, after which the diaphragm was sutured to the chest wall. The incision was closed without drainage.

The condition improved greatly following the operation. The mouth temperature was from 100 to 103.4 degrees F. for 3 or 4 days. On the third day following operation, evidence of a slight amount of fluid in the left chest was confirmed by X-ray examination which also showed clouding suggesting a localized pneumonic process in the right lung. Fever, however, was the only clinical evidence of pneumonia which developed. The patient continued to improve rapidly and was discharged in good condition on the thirteenth day. Examination at that time showed a decrease in the amount of fluid in the left chest; the apex beat of the heart could be felt 2 fingers' breadth to the left of the sternum in the fifth interspace; the left lung seemed to be expanding. X-ray examination again confirmed the clinical findings.

Recent reports from Dr. Hudnutt, the family physician, state that the boy is apparently as well as ever.

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A NEW METHOD OF OBTAINING COSTAL CARTILAGE FOR PLASTIC AND RECONSTRUCTION SURGERY

By JOSEPH D. KELLY, M.D., F.A.C.S., New York

MUCH has been written upon the subject and many instruments have been introduced for plastic operations during the past few years. Hence one hesitates about introducing something new or presumably new into the armamentarium of the plastic surgeon, unless it has a place, and I did not offer these instruments for consideration until they had been used by other surgeons and had met with their approval.

The difficulties which I experienced in doing nasal plastic surgery by the old method had been the resecting of a piece of rib or the removal of a piece of costal cartilage. The time and energy consumed in resecting a rib, and the danger of perforating the pleura seemed to me rather out of proportion in view of the fact that after its removal the bone had to be shaped to the size required. Also the removal of a piece of costal cartilage consumed an equally unreasonable amount of time and patience with a large element of uncertainty as to whether the piece removed was going to fulfill the requirements of the case at hand.

Some few years ago after becoming thoroughly converted to the use of costal cartilage, I started the search for a simpler and better method of removing cartilage. My idea was a chisel, but the surgical instrument houses had no such chisel and could not understand the type of instrument I wanted. The answer came while I was watching some wood carvers work at an exhibition in New York. The chisels used by them seemed to be just the thing I was looking for. They were sharp, the proper size, well balanced, easily handled, and could be sterilized.

I purchased some of these chisels and experimented with them on cadavers. The result was good. I found that they could be forced over the surface of the pleura without injuring it, and that the pleura was punctured only when a deliberate attempt was made to do so by forcing the chisel backward or downward at right angles to the chest wall. They would also deliver a piece of cartilage of a size, shape, and thickness corresponding to the size of the chisel used.

This gave me encouragement but, not having an unlimited supply of cadavers, I had to find a substitute to practice upon. The large yellow turnip

Fig. 1. Showing the method of measuring the length of the transplant.

Fig. 2. Showing application of a piece of turnip to plaster model to determine its fitness for the case.

Fig. 3. Showing the insertion and placement of cartilage transplanted in simple saddle-back nose.

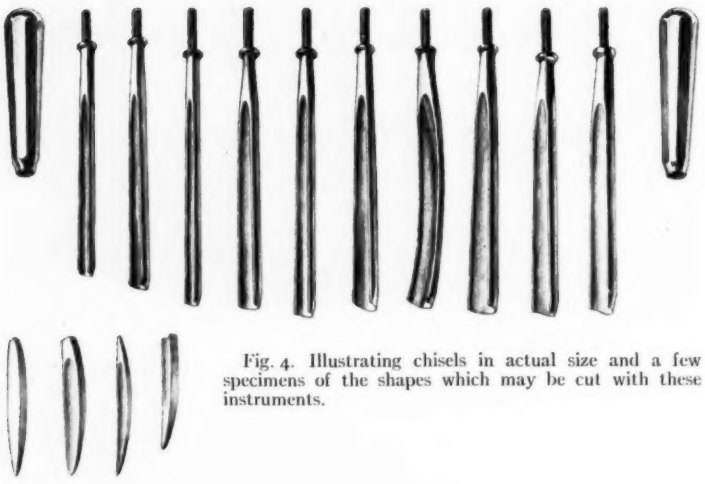

Fig. 4. Illustrating chisels in actual size and a few specimens of the shapes which may be cut with these instruments.

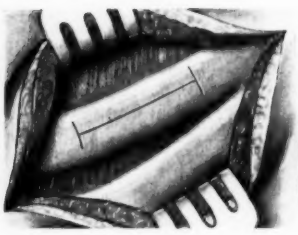

Fig. 5.

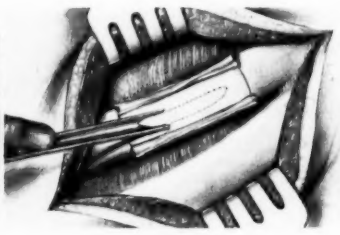

Fig. 6.

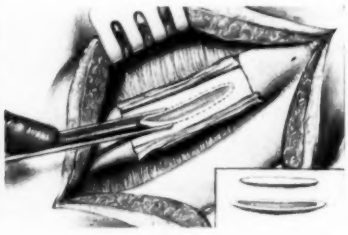

Fig. 7.

Fig. 5. Showing exposure of rib with incisions made in the perichondrium.

Fig. 6. Removing cartilage for simple transplant

Fig. 7. Showing the method of removing the cartilage for the cases in which the cartilage is required to be grooved.

proved the best substitute and after trying my skill on a number of turnips, using first one chisel and then two chisels of different sizes, I found I could cut a piece of turnip similar to the size, shape, and thickness of a piece of cartilage needed for nearly any case requiring a cartilage transplant.

Going back to the cadavers, I found that the chisels worked just as well on the costal cartilage except that a little more force had to be used.

A large piece of cartilage might be tunneled to fit the nasal bone or beveled to fit the frontal bone. It might be thin on the end, thick in the center, or vice versa with a contour similar to that of the normal nose. This could be accomplished before the piece of cartilage was completely removed from the sternum. This did away with the old method of getting a piece of cartilage by the use of a knife, elevator, and a pair of forceps and then attempting to shape it with various instruments at the time of operation, a procedure very often requiring much time during which the patient is under an anæsthetic.

It was also evident that the shapes removed by one or more chisels might be used for purposes such as the complete or partial reconstruction of a nose, the reconstruction of an ear, the formation of eyelids, postoperative frontal sinuses, deformities, elevation of depressed scars, and the tunneling of soft tissue.

The number of chisels in the set at this time is ten. They are illustrated in full size in the drawing. They have been nickel plated and threaded on their shanks to fit the handles shown. As it is

very seldom necessary to use more than two chisels in an operation, only two handles were made. After having used these chisels for some time I noticed that the cutting edge became quite serrated, and on inquiry at my instrument makers, I found that this could be overcome by having the chisels made of a better grade of surgical instrument steel. I believe this difficulty has been overcome in the instrument produced by Tieman and Company.

The method which I have developed for the use of these chisels is as follows:

A plaster cast is made of the patient's face by the use of quick setting dental plaster. If the case is a simple saddle back nose it does not take long to determine what steps to follow at the time of the operation. The cast, Joseph's rule, chisels and yellow turnip usually solve the problem to the satisfaction of yourself and the patient. The first step is to measure the distance from the frontal bone to the tip of the nose. Decide whether you want the transplant to be 4, 4½ or 5 centimeters. Then measure this distance on the cut surface of the turnip at both ends of the diameter and connect these points with lines made with some sharp instrument. You then select the chisel or chisels which you believe will be suitable for the case and cut several pieces of turnip and apply to the cast and note the result. It may be necessary to bevel one end to fit the frontal bone or taper it more at the tip. After you have decided upon the sort of piece you want, it is well to practice cutting that particular shape as accurately and as quickly as possible. This is your model of the piece of cartilage you want to deliver at the time of operation. You know that if you can deliver a piece of cartilage of that size and proportion your operation is going to be a success. I have made it a practice to preserve this model by covering it with paraffin, taking it along with me to the operating room for reference and comparison.

If the nasal bones are prominent at any point or if the septal cartilage is poor it is well to groove the cartilage before cutting it in order to make it conform better to nasal bones and prevent sliding.

If the case is other than a simple saddle nose, that is, one in which it will be necessary to remove a hump, or cartilage twist, or remove some of the ascending process of the superior maxillæ, a little different method is followed. In a case of this sort we make a second mold, that is a partial plaster mold of the nose, eyes, and mouth of the original plaster cast. By using plastine to fill this mold we can make as many impressions of the nose as are necessary for the study of the case.

Markings are made on the plastine model to correspond to the position and size of the nasal bones and the ascending process of the superior maxillæ. Then with an ordinary spatula or clay modeling tool the plastine is removed from the model at the points of election. This gives you some idea of how the nose will look when these bones are removed. The next step is to cut from the turnip a model of the cartilage transplant to be made, place this in position on your plastine model and you have something definite by which to judge what the result of your operation will be.

SUMMARY

I believe that I may safely say that by this method we eliminate the disadvantages of the old way of removing cartilage, because with the use of these chisels the cartilage may be removed much more easily, more rapidly, with less danger, and more accurately. This method makes it possible for a greater number of surgeons to do the simpler cases of nasal plastic surgery with more confidence in themselves and with more satisfaction to their patients.

This work has been developed through the courtesy of and on the clinic of Dr. Harmon Smith at Manhattan Eye and Ear Hospital, New York City.

ETHYLENE–OXYGEN ANÆSTHESIA

A Report of 2,750 Cases

By CLYDE I. ALLEN, M.D., and MARY MURRAY, R.N., Detroit, Michigan

From the Department of Surgery, Henry Ford Hospital

SINCE the experimental and clinical studies of Luckhardt and Carter (9 and 10) and Brown (1 and 2) demonstrated in 1922 the possibilities of ethylene-oxygen as a general anæsthetic, its value has become fairly widely accepted, although many objections have been raised against its use and some dangers pointed out. We have felt that a critical review of its use in 2,750 consecutive cases might aid in establishing its proper place in relation to the other general anæsthetic mediums.

An effort has been made to evaluate its special advantages or disadvantages which might be evident during or following the period of anæsthesia. No attempt to select certain particularly favorable types of cases has been made. It has been used in a great variety of operations, from minor surgical procedures to the more extensive major operations. These have included general surgical, gynecological, urological, orthopedic, and otolaryngological operations.

The anæsthetics were for the most part administered by professional trained nurse anæsthetists, although about twenty per cent of the anæsthetics reviewed were given under supervision by junior members of the surgical staff.

The same machines[1] formerly utilized for nitrous-oxide-oxygen administration have been used without the addition of any special safety devices or attachments, as suggested by Luckhardt (7) and by Lewis and Boehm (6).

Ethylene manufactured by a manufacturer of chemicals has been used and found quite satisfactory. Luckhardt's (8) warning, however, that the production of ethylene on a commercial basis might result in a gas less pure than that produced in the experimental laboratory must be borne in mind.

At times there was noted a difference in the rate of induction and in the severity of the postoperative nausea, with the use of various shipments of the gas. This might quite readily be attributed to minor variations in the relative purity of the ethylene but on this we have no exact data. It is true, however, that the oily residue which collects in the reducing diaphragm is variable in amount and that the usual colorless gas occasionally has a light blue smoky appearance.

[1]Heidbrink-Surgical Unit. McKesson-Model G-Surgical Unit.

EXPLOSIBILITY

The most serious objection to the use of ethylene-oxygen is its explosibility. According to Brown (2) the maximal explosibility is reached when the proportion is 15 of oxygen to 1 of ethylene. This same observer has pointed out, however, that for the atmosphere of an operating room to become saturated with such an explosive mixture, it would require an unheard of and prodigal escape of ethylene. Brown has reported further that a minimum of 40 to 45 per cent of oxygen is required for an explosive mixture and that the explosibility increases with higher percentages of oxygen. He states (3) that in a room of 2,700 cubic feet at least 6 hours of continuous anæsthesia would be required to result in an atmospheric ethylene content of from 5 to 10 per cent, sufficient to result in an explosive mixture.

By reason of its weight the gas does not diffuse very rapidly and may hang as an almost or entirely invisible cloud in a quiet room following its escape. It is therefore quite true that the use of free flame, X-ray machines, electric fans and actual cauteries is extremely dangerous. When the latter are essential there is no middle ground and another type of anæsthesia must be used. These sources of danger can easily be eliminated.

The static spark, however, resulting as it does from differences in electrical potential of two charged bodies brought into close proximity, has been the subject of much debate in its relation to ethylene, both as to its being a real source of danger and as to means by which this danger can be eliminated. We have demonstrated with an electroscope that this difference in potential between bodies, both animate and inanimate, does exist in a greatly varying degree. The discharge that may occur between these bodies furnishes an ever-present source of danger, provided precautions are not taken against it. More or less elaborate means of grounding the tables, machines, doctors, nurses, and attendants have been devised and are theoretically effective (6 and 7). The very elaborateness of some of these protective mechanisms has to a certain extent argued against

their general acceptance. We believe with McKesson (11) that sufficient precaution has been taken when certain rules are observed in beginning and terminating the administration of the ethylene-oxygen mixtures. He strongly advises applying the mask to the face of the patient with tube and mask entirely free of the ethylene-oxygen mixture, before the ethylene is turned on for the induction, thereby causing a harmless preliminary discharge should a difference in potential exist. The constant contact of the anæsthetist, mask, and patient thereafter maintains an equality of potential, and eliminates this area as a source of production of a static spark. In terminating the anæsthetic, precaution should be taken to turn off the tanks and release the pressure on the supply bags before the mask is removed, thereby stopping the constant flow of the ethylene-oxygen mixture from the tube.

During the time covered by this report, two explosions have occurred, neither of which took place during anæsthesia, and neither doing any harm except minor damage to the machines. On the first occasion, the explosion occurred with a loud report and with a shattering of the glass covering of the mixing chamber. Two holes large enough to allow the insertion of a finger were torn in the rubber tubing. Later investigation revealed that the ethylene and oxygen had not been entirely turned off. The explosion occurred as the anæsthetist was moving the machine through the door of the anæsthetic room into the corridor and after the machine had been moved about 8 feet. It had been standing idle about one hour at the time the explosion occurred. The most satisfactory explanation of this accident is that a static spark must have resulted as the anæsthetist grasped the handle of the door or as she again grasped the machine or that a spark was produced as some part of the machine struck the side of the doorway in passing through. No personal injury resulted other than a few pin point cuts on the hands and face of the anæsthetist, made by flying glass. No free flame or smoke was noticed and no evidence of such remained about the machine. The neglected precaution necessary to the prevention of this accident was the turning off of the gas mixture at the completion of the preceding anæsthesia.

The second explosion occurred more recently and, as with the earlier one, no harm was done other than the breaking of the glass in the mixing chamber and the production of three holes in the rubber tubing (Fig. 1). In this instance an anæsthetic had just been completed and the mask and tubing had been laid back over the framework of the machine. The ethylene had previously been turned off. The explosion occurred as the anæsthetist reached to release the pressure from the supply bag. At this time the oxygen was still turned on, having been used to hasten the patient's return to consciousness. This occurrence might be explained by assuming that the pressure bag still contained sufficient ethylene to form a highly explosive mixture with the oxygen and that the pressure remaining in the bag was sufficient to maintain a constant though diminishing flow from the mask. A spark probably occurred as the anæsthetist's hand came in contact with the thumb screw of the supply bag and ignition of the gas-oxygen mixture followed. A loud report resulted and momentarily there was a bluish flame at the mixing chamber which quickly flickered out without doing any damage. No evidence of smoke or flame remained on the mixing chamber, mask, or tubing. In this case, turning off of all pressure both from the tanks and from the pressure bag before the mask was removed would probably have prevented the explosion. No personal injury resulted from this accident.

Fig. 1. Hole in rubber tubing after explosion.

ODOR

Objections to the use of ethylene because of its offensive odor are frequently voiced. This feature ceases to be annoying after a very short contact with the gas. Whether the olfactory mechanism develops a special tolerance to this particular odor can only be surmised, but it is true that those to whom the odor was most offensive rapidly came to disregard it altogether. So far as the patient is concerned, of course, his first contact may be his only one. It has been brought out, however, by questioning many patients, some of them members of the medical and nursing staff, that after the first few breaths no odor whatever was noticed. No unpleasant postanæsthetic memories of the odor have been reported. This does not seem to be legitimate objection to the use of ethylene.

MEDICATION

The pre-operative medication has usually consisted of morphine sulphate grain $^1/_6$ and atropine

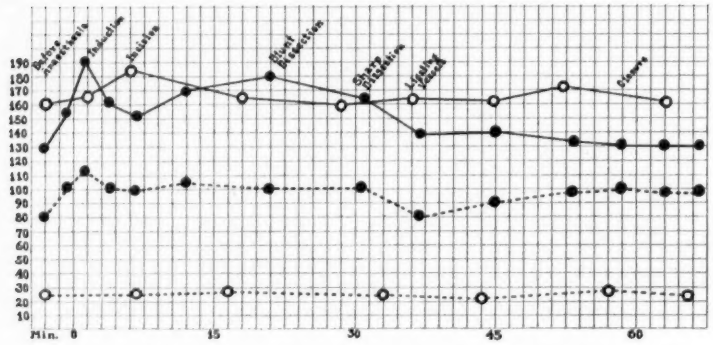

Chart 1. Case No. 68105. Age 29. Double lobectomy—hyperthyroidism. Basal metabolism rate +47%. ○———○ pulse; ●———● systolic blood pressure; ○ ---------- ○ respiration; ●----------● diastolic blood pressure.

sulphate grain $^1/_{100}$, given about 15 minutes before the anæsthetic was begun. Where immediate anæsthetizing was desired, morphine grain ¼ was generally used. It has not been found necessary to use opiates in repeated doses, preceding the anæsthesia, in order to make possible a quiet and rapid induction.

INDUCTION

In most instances the period of induction has been from 3 to 5 minutes. This rate of induction has not necessitated pushing the gas to a degree to add to the discomfort of the patient. Ordinarily, no period of excitement was observed other than slight and easily controlled movements of the arms or legs and more frequently the process resembled that of sleep. Nausea and vomiting have been seen infrequently during induction even with emergency, unprepared patients, who may have taken food recently. The anæsthetic was usually started with a mixture of 90 per cent ethylene and 10 per cent oxygen. Because of the danger of the possible production of a static spark, the routine has been established of placing the mask on the face previous to turning on the gas. While it might be a little more pleasant to the patient to have a less abrupt introduction to the gas, many prefer this method to a more gradual approach and at most the period of unpleasantness is very short.

When the patient has become thoroughly anæsthetized the mixture is gradually altered, usually to approximately an 85 per cent–15 per cent ratio, on which mixture, anæsthesia of sufficient depth can be maintained to produce excellent relaxation in most cases. Frequently it has been possible to reduce the ethylene content to as low as 75 per cent and still maintain satisfactory relaxation. In those cases in which it has been necessary to use a richer mixture throughout the operation in order to maintain a desirable relaxation, no deleterious effects have been observed. The criterion in regulating the relative percentages of the gases has been the composite picture of the patient's condition, as shown by the respirations, pulse rate and quality, the circulatory condition and the degrees of relaxation. When anæsthesia becomes too deep the respirations usually become rather stertorous and later slow and shallow, and cyanosis develops. As has been noted by other observers, the skin usually remained a good color and cyanosis was rare when just enough of the ethylene was used to maintain good anæsthesia. The moisture of the skin was seldom greater than normal and was markedly less than that ordinarily encountered with ether anæsthesia.

At times it was found advisable because of unsatisfactory relaxation to augment the ethylene-oxygen with ether. This was done in 160 of the 1,421 major operations or in 11.18 per cent of the cases. The average amount of ether used was 2.19 ounces and was just sufficient to give slightly better relaxation through a particularly trying period of the operation. In a few instances it was found necessary to change entirely to ether anæsthesia. In the face of this occasional necessity, it should be borne in mind that even with ether, perfect relaxation is not always obtainable. The various types of operations in which ether was required will be discussed below.

PULSE

The pulse rate and quality were not appreciably affected by ethylene in the amounts ordinarily

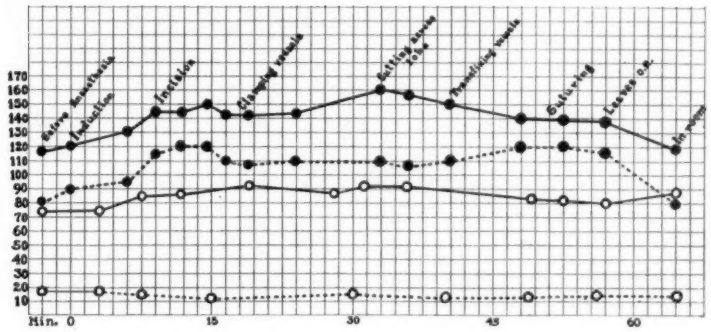

Chart 2. Case No. 69416. Age 55. Excision of right lobe and isthmus—non-toxic goiter. ○———○ pulse; ●———● systolic blood pressure; ○----------○ respiration; ●----------● diastolic blood pressure.

required for anæsthesia. The ethylene itself is evidently not a cardiac stimulant and with the use of ordinary amounts, alterations in the pulse are those which are more easily explained as being due to other influences, such as emotional stimulation during induction, stimulation from the initial incision, pulling on the peritoneum or palpation of the viscera (Charts 1, 2, 3 and Table I). With persistent cyanosis, the pulse does become more rapid in an effort to overcome the decreased oxygenation. Myocardial failure would undoubtedly follow were the anoxæmia not relieved.

BLOOD PRESSURE

In attempting to evaluate the various effects of any anæsthetic medium, the many factors concerned must be borne in mind. Chiefly, it must be remembered that operative preparations and procedures in themselves may cause great changes in the pulse, respiratory rate and excursion and blood pressure. To these may be added the effects of fluid loss and of fear and posture, as noted by Clark (4). He has reported that ether and chloroform act in a fairly uniform way under uniform conditions, the former causing a fairly marked cardiac stimulation with resultant rise in blood pressure and later a depressor effect and corresponding fall, the latter being very gradual in onset and effect. Chloroform has only a slight stimulating effect and a tendency to produce a more rapid and profound depression with accompanying fall of blood pressure. An attempt to determine the effect of ethylene-oxygen on the blood pressure has been made. Readings were taken before the induction of anæsthesia and at repeated intervals during the operations (Charts 1, 2, 3 and Table I).

The chemical combination of ethylene with any of the body tissues, especially the blood, is extremely unstable, as is shown by the rapid escape in an unchanged form in the expired air, with a corresponding rapidity of regaining of consciousness. Because of this instability it would not be expected that the effect on the nervous centers would be very marked. Our readings have been made on patients having widely different types of operations and in none of these were there changes in the blood pressure which we did not feel were more likely due to influences other than that of the ethylene. In most cases there was found to be a fairly marked initial rise of from 10 to 40 millimeters at the beginning of the induction. The fact that the rise occurred before sufficient time had elapsed to allow the absorption of more than the smallest amount of ethylene would eliminate it as the cause. It was undoubtedly due to the fear or excitement of the approaching procedure. The later changes were most easily explained as due to operative manipulations, such as incising the skin, pulling on peritoneum, delivering a lobe of the thyroid gland, curetting bone, etc. As will be noted in the charts, also, the blood pressure fairly rapidly returned to approximately the pre-operative readings, once the manipulative or stimulative steps of the operations were finished.

BLEEDING

In the early cases it was believed that there was perhaps some slight tendency to increased bleeding. Subsequent and continued observations have not substantiated this feeling, however. Except for the occasional patient who does seem to require more than the ordinary amount of hæmos-

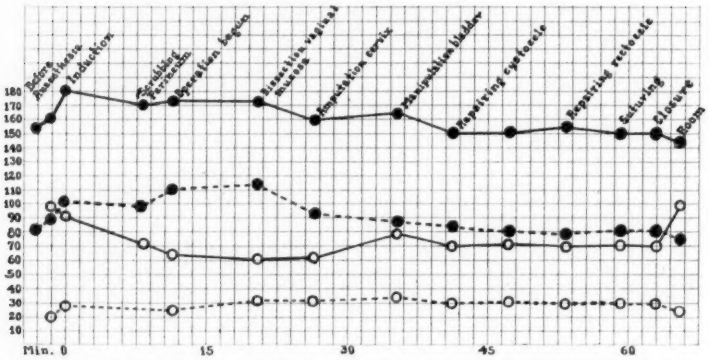

Chart 3. Case No. 65592. Age 60. Perineorrhaphy and interposition operation. ○———○ pulse; ●———● systolic blood pressure; ○----------○ respiration; ●----------● diastolic blood pressure.

tasis, the bleeding has not been abnormal. These instances might well be the result of individual variations of blood pressure or tonus of blood vessel walls as may be noted with the use of any type of anæsthesia. Horsley (5) has reported no alterations in the blood coagulation time following ethylene anæsthesia.

USE IN MINOR SURGERY

In this series of 2,750 cases, 1,329 anæsthesias were used in minor surgical procedures. These included 539 incisions and drainages of abscesses, 39 minor sequestrectomies, 67 minor amputations, 76 closed reductions of fractures or dislocations, 76 manipulations, 85 dressings, 66 repairs of traumatic injuries, 105 paracenteses, 30 cystoscopic examinations, 45 extractions of teeth and a miscellaneous group of 201 made up of radium insertions, excisions of moles and small subcutaneous tumors, biopsies, pelvic examinations, lavages of infected joints, etc.

Ethylene has proven especially satisfactory for the types of operations just mentioned. The great value lies in the fact that rapid anæsthetizing can be accomplished and rapid regaining of consciousness follows, with little or no residual morbidity, so that minor operations may be done in the out-patient department and the patients be able to return home in a short time. Of this minor group, 879 were male and 450 were female patients. The ages varied from 9 months to 77 years. In 919 of these cases the anæsthetic was given by professional anæsthetists, and in 410 by junior members of the surgical staff.

A great majority of the patients represented by the group of 539 for incisions and drainages were those coming in with abscesses of the hands or furuncles requiring immediate opening, regardless of the fact that food may have recently been taken. A very light anæsthesia was sufficient to permit these procedures. There was very little tendency to move an extremity which was being incised even though the narcosis was obviously superficial. The regaining of consciousness was extremely rapid and nausea and vomiting by no means always an accompaniment. When vomiting occurred the retching could usually be quickly overcome by the taking of a few breaths of fresh air.

With this entire group of minor operations, it was noted that the after-effect was usually a pleasant one. While the patients awoke without any period of excitement or struggle, it was usually with a sense of well being, at times enhanced by the residual of dreams of a rather extravagant but pleasing character. Complete regaining of consciousness occurred in 2 to 3 minutes and this time could be decreased by a few inhalations of pure oxygen. It has been observed that the use of oxygen during the period of reaction decreases the liability of nausea and vomiting.

For manipulations of joints and closed reductions of fractures or dislocations, ethylene has proven valuable. Excellent relaxation may be obtained and it has the additional advantage of permitting frequent repetitions should this be desired, without the objectionable features of ether. For doing extensive, painful, or disquieting dressings this gas has been ideal. Only slight anæsthesia has been required. It has been employed daily over a considerable period of time in some cases, without any discovered deleterious effects. Here, too, the rapid regaining of consciousness with little or no nausea has been of value. The

TABLE I

Case No.	Operation	Systolic Blood Pressure								Diastolic Blood Pressure							
		Before	Induct.	15 min.	30 min.	45 min.	60 min.	Leave O. R.	In room	Before	Induct.	15 min.	30 min.	45 min.	60 min.	Leave O. R.	In room
69466	Drainage, knee	120	158	142	178			136		76	88	92	100			82	
65592	Perineal repair	154	180	172	162	150	150	150	146	82	100	110	90	82	80	80	76
69001	Appendectomy	150	142	136	136			130		70	96	92	96			90	
69287	Plastic on arm	150	150	145	135	130	120	120	128	110	115	115	90	100	90	90	98
69416	Thyroidectomy	118	120	150	155	145		140	120	80	90	120	110	115		115	80
58763	Exc. cyst urethra	116	150	126	116	114		128		66	110	74	80	74		80	
68105	Thyroidectomy	130	190	172	165	140	130	130		80	110	100	100	90	100	98	
57280	Reopening mastoid	100	116	128	120	116	106		112	60	80	90	60	50	56		80
69050	Hernioplasty	148	150	150	110	116			120	88	84	80	76	60			80
54741	Appendectomy	130	130	142	140	128			126	80	85	88	88	86			84
80650	Thyroidectomy	184	194	200	160	140				114	130	140	130	108			
80214	Thyroidectomy	130	154	164	160	148				80	92	102	90	90			

Case No.	Operation	Pulse								Respiration							
		Before	Induct.	15 min.	30 min.	45 min.	60 min.	Leave O. R.	In room	Before	Induct.	15 min.	30 min.	45 min.	60 min.	Leave O. R.	In room
69466	Drainage, knee	104	108	104							28	24	28				
65592	Perineal repair	96	90	64	70	70	70	70	100	20	28	28	32	30	30	30	24
69001	Appendectomy	128	96	96	94												
69287	Plastic on arm	100	100	120	124	124	140	124									
69416	Thyroidectomy	74	74	90	90	85		80	88	18	18	15	16	15		15	15
58763	Exc. cyst urethra	68	88	80	88	80		100		18	18	20	24	20		20	
68105	Thyroidectomy	160	165	172	165	162	165	160			24	26	26	22	28	24	
57280	Reopening mastoid	72	136	72	72	72	88		100	16		20	26	26	18		
69050	Hernioplasty	64	64	70	90	84		70									
54741	Appendectomy	96	100	88	88	88			94	18	22	26	24	24			24
80650	Thyroidectomy	100	100	130	140	140				20	24	20	20	22			
80214	Thyroidectomy	150	130	160	150	130				20	26	30	20	20			

repeated use, even at frequent intervals, does not bring on an increasing dislike of the gas, nor does the minor postanæsthetic discomfort tend to become more aggravated. This practice does not lead to the development of a tolerance with a resultant decrease of effectiveness.

As the anæsthetic for opening ear drums in young children ethylene-oxygen has been found entirely satisfactory and is safely employed with very young babies. Here, too, only very light anæsthesia is required.

For the extraction of teeth this gas appeared far superior to the nitrous-oxide-oxygen mixture. Excellent anæsthesia has been maintained with the nose-piece over a considerable period, the patient meanwhile not suffering from any degree of cyanosis.

USE IN MAJOR SURGERY

Of these 2,750 cases recorded, 1,421, or 51.61 per cent, were classified as major surgical procedures. These included 412 thyroid, 379 abdominal, 123 urological, 116 orthopedic, 95 gynecological, 70 breast, 45 mastoid, 21 rectal, 20 chest, and 8 brain operations. In addition, there was a group of 132 which did not fall into any of the general classes of this major division. There were 662 male and 759 female patients. The ages of the patients ranged from 3 to 78 years. In 1,290 cases the anæsthetic was given by professional

TABLE II

Type of operation	Number of operations	Number with nausea and vomiting	Per cent with nausea and vomiting	Number with ether	Per cent with ether	Average duration operation minutes	Average number times vomited	Average duration with nausea and vomiting hours
Gall bladder	98	61	62.2	49	50	61	3.7	18.1
Thyroid	412	222	53.8	0	0	49	2.7	10.9
Appendix	100	52	52	18	18	40	2.5	11.5
Pelvic	95	43	45.2	21	22	50	2.3	11.8
Orthopedic	116	47	40.5	9	8	65	2.1	8.5
Stomach	37	10	27	20	54	90	3.2	17.6
Intestine	19	5	26.3	4	21	48	3.6	16.2
Urological	123	32	26	14	11	64	2.9	12.5
Miscellaneous	421	91	21.5	6	1.4	63	2	7.1

anæsthetists, and in 131 by junior members of the surgical staff.

Of the 412 thyroid operations which were done on 333 patients, 55 were polar ligations, 31 were single lobectomies, 294 were double lobectomies and 32 were secondary closures. In none of these was ether used as an adjunct anæsthesia and only in the early cases anæsthetized with ethylene was ½ per cent novocain used locally in conjunction with the gas. This latter practice was abandoned in a comparatively short time. Of the 333 patients having thyroid operations, there were 132 with hyperplasia of the gland with varying grades of hyperthyroidism, 98 with single or multiple adenoma without hyperthyroidism, 52 with adenomata, and 18 with simple colloid goiters. The ages of these patients varied from 16 to 70 years. Of the 184 patients with toxic symptoms the basal metabolic rate varied from plus 10 to plus 92 per cent, an average being about plus 45 per cent, pre-operative, following a variable period of rest and treatment in the hospital. A great many of these patients had definite cardiac damage as shown by clinical and electrocardiographic surveys, some of them with auricular fibrillation.

The advantages of ethylene in goiter operations, especially in those with a high metabolic rate, are: first, the ability to secure a rapid, quiet induction without a period of excitement or labored, choking respirations; second, the ability to use it over a long period of time without any apparent stimulative or depressive effect from the gas itself; third, a rapid regaining of consciousness with a great deal less postanæsthetic nausea and vomiting than previously encountered with the use of ether; and fourth, the avoidance of the excitement and other mental disturbances which frequently occur with the use of local anæsthesia, especially with nervous, high-strung patients. Patients with a considerable degree of myocarditis stood this anæsthesia well. It has not been felt that hæmostasis has been any more difficult to obtain than when ether was used.

Of the 379 abdominal operations, 100 were appendectomies, 94 cholecystectomies with 54 of which appendectomy, also, was done, 109 herniorrhaphies, 32 gastro-enterostomies, 16 abdominal explorations, 14 colostomies, 5 intestinal resections, 4 cystico-choleo-duodenostomies, 3 excisions of gastric ulcers, and 2 pyloroplasties. The advantages of a quick, easy induction and a rapid regaining of consciousness were evident here as in other instances. Probably the greatest recommendation for ethylene in this group lies in the fact that necessary surgical procedures may be carried out without the anæsthesia itself acting as an aggravating influence on such coexisting pathological conditions as chronic myocarditis, arterial hypertension, chronic nephritis and chronic bronchitis. With the latter condition, of course, any gas probably has some irritating effect, but without question it is immeasurably less with ethylene than with ether. In the great majority of this group, entirely satisfactory relaxation was obtainable. In 28.4 per cent of the entire group, ether was required to decrease the muscular tension during particularly trying stages of the operations. The average amount of ether used with the 109 patients requiring it was 2.13 ounces. As will be readily seen, this amount is negligible as compared with the total amount ordinarily required for major abdominal surgery. Of these 109 patients, 18 had herniorrhaphies, 49 had gall-bladder operations, 20 had operations on the stomach, 18 had appendectomies and 4 had intestinal operations. It will be noted that the gall-bladder and stomach operations add greatly to this group, 50 per cent of the former requiring

an average of 2.14 ounces of ether and 54 per cent of the latter requiring an average of 2.25 ounces. Of the hernioplasties and appendectomies, approximately 18 per cent required an average of 2 ounces of ether. While the failure of an anæsthetic medium to give completely satisfactory relaxation in 28.4 per cent of the abdominal cases may seem a considerable indictment, the amounts required were rather small and the cases which represented the largest percentages were those in which complete relaxation even with ether is most difficult to obtain. No attempt has been made to struggle through an operation rather than use ether, for the combination of the two mediums when necessary, has been entirely satisfactory and the continued use of ethylene-oxygen following the use of ether aids in the more rapid elimination of the latter, so that the post-anæsthetic nausea and vomiting are not greatly if at all aggravated by this addition.

The ages of the patients in this abdominal group ranged from 6 to 77 years.

Of the 123 urological operations there were 23 suprapubic, one-stage prostatectomies, 16 nephrectomies, 12 first-stage and 12 second-stage prostatectomies and 10 nephrotomies. The remainder of this group was made up of a rather wide variety of operations. As has been previously pointed out by other observers, ethylene is especially valuable in this branch of surgery because many of the patients falling in this division are well advanced in years and come for treatment only after considerable kidney damage has occurred. With many of these patients with prostatic enlargement and accompanying urinary tract infection the functional activity of the kidneys is very low. In addition to this, the age of the patients makes hospitalization except under the best of care a dangerous procedure because of pulmonary complications. The use of ethylene-oxygen, rather than ether, relieves both the kidneys and lungs of the added chemical irritation. With these patients, too, the fluid intake is especially important. With ethylene anæsthesia it is possible to begin fluid intake by mouth, almost immediately postoperatively. If nausea and vomiting occurs it is seldom of a serious character and usually short in duration as compared with that following the administration of ether. Maintenance of body fluids is extremely desirable with all of these patients. The use of ethylene results in much less loss by perspiration than that experienced with the use of ether. Relaxation is quite good in most instances. Of this group of 123, ether was given in 14 cases or 11.3 per cent. The average amount used was 2.21 ounces. The ages of these patients ranged from 13 years to 78 years.

In this series, there were 116 orthopedic operations which included 25 major amputations, 23 major arthrodeses, arthroplasties or arthrotomies, 22 osteotomies, 19 tenoplasties, 18 open reductions, 5 major closed reductions and 4 repairs of hallux valgus. No especial comment need be made concerning the use of ethylene in this group. It was found entirely desirable and the advantages enumerated in the other groups were equally obvious in this one. Relaxation was quite good even where the larger muscle groups were concerned. In 9 of the 116 cases or in 7.6 per cent, ether was used to reinforce the ethylene, the average amount being 2.77 ounces. The ages ranged from 8 years to 68 years.

Of the 95 gynecological operations, 21 were supravaginal hysterectomies, with 3 of which appendectomies were done and with 5 of which salpingo-oophorectomies were done; 19 were salpingo-oophorectomies, with 14 of which appendectomies were done; 15 were cervical amputations; 14 were perineal repairs; 9 were excisions of uterine or cervical polypi; 7 were dilatations and curettages; 5 were uterine suspensions; 4 were interposition operations with perineal repairs; and one was a pan-hysterectomy. With this group, the observations were similar to those made with the other types of cases. When working deep in the pelvis the relaxation is occasionally not so great as may be desired and is less complete than that obtainable with ether. Of these 95 operations ether was used in 21 cases or in 22.1 per cent, the average amount used being 2.28 ounces. No especial difference in the amount of bleeding was noted, from that encountered with the use of ether. Here the ages ranged from 13 years to 73 years.

Of the rather varied assortment of operations which made up the balance of this major group, no especial comment need be made. The advantages enumerated in the various groups above were equally apparent with these and the problem of relaxation was less important.

COMPLICATIONS

The value of any anæsthetic medium must be based on the postoperative effects as well as on the results obtained during the operations. In these studies no postoperative complications involving the cardiovascular, genito-urinary or nervous systems were encountered which we felt could in any way be attributed to the ethylene-oxygen used. Especial concern was exerted regarding the complications which might arise as

a result of irritation and altered functions of the respiratory and gastro-intestinal systems.

Of the postoperative pulmonary complications there were found, 1 case of lobar pneumonia, which made a good recovery, 4 cases of bronchopneumonia, 2 of which made good recoveries and 2 of which died, and 1 case of bronchitis, which made a good recovery.

The patient who developed lobar pneumonia involving the right base was a male, aged 28, who had had an excision of a left renal calculus. On the afternoon of the day of the operation his temperature rose to 100 degrees and on the first postoperative day reached 106 degrees. Examination revealed a consolidation of the left base. He made a good recovery and on the twelfth day postoperative his lungs were clear and his temperature was normal. Here, evidently, was a patient with a fairly virulent organism present in his upper respiratory tract before operation. The slight irritation of lung tissue combined with the shock of operation was enough to allow the bacteria to do sufficient damage to lead to consolidation.

Of the 4 patients developing postoperative bronchopneumonia, 2 recovered and 2 died. Of the 2 who died, 1 was a man of 54 with marked hyperthyroidism and resultant myocarditis who was operated upon because of a general peritonitis, which resulted from a perforation of a duodenal ulcer. He died on the third day postoperative. The pathology in the lungs was not marked clinically, but autopsy revealed the presence of a lobular pneumonia of both bases. The general peritonitis and myocarditis certainly contributed largely to this patient's death.

The second fatality of this group was a male of 56 who was operated upon because of a strangulated hernia. The operation was somewhat prolonged while the effect of heat on the cyanotic intestine could be determined. In this anæsthesia, about 3 ounces of ether, also, were used. The patient rapidly developed signs of pulmonary inflammation following operation and died in 53 hours. Postmortem examination showed the portion of the intestine which had been strangulated to be in good condition. Examination of the chest revealed the presence of a bilateral lobular pneumonia and bilateral acute exudative pleurisy. One might consider the possibility of emboli from a mesentery vessel involved, causing multiple foci in the lungs, but the course was so acute that it seems more likely that the bacteria were there and that the insult to the parenchyma was sufficient to allow a rapid production of multiple areas of consolidation. The ether used produced a complication which made an exact evaluation of the effect of the ethylene more difficult.

Of the 2 patients who recovered, 1 was a female, aged 30, who had an excision of an immense tumor of the left abdominal wall. Because of the loss of tissue, the closure was extremely difficult, the operation requiring 2½ hours. The abdomen was snugly strapped to reduce the strain on the sutures. On the day following operation the temperature rose to 103 degrees with a corresponding elevation of pulse rate and a respiratory rate of 40. Examination of her chest revealed the signs of a bronchopneumonia of the right base posteriorly. The course was uneventful and temperature, pulse rate, and respiratory rate were normal on the eighth day and remained so. Recovery was complete. The length of the operation combined with the limiting of the respiratory excursion by the necessary strapping probably contributed to the complication.

The other of these two patients was a woman of 26 who had had a cholecystectomy and appendectomy. Operation lasted 55 minutes. On the afternoon of the day of operation her temperature rose to 102 degrees and signs of some consolidation in the right base posteriorly were evident. The pulse rate was proportionately elevated. Both temperature and pulse rate gradually fell to reach normal on the seventh day postoperative. Temperature remained normal and convalescence was otherwise uneventful.

The patient who developed bronchitis was a man of 69 who had had a suprapubic prostatectomy. The area involved was the left base. The temperature rose to 102 and râles were numerous. They cleared up rapidly, however, and by the third day postoperative the chest was clear and the temperature normal and the patient made a good recovery.

There were in this series, I am sure, other patients who for a variable time had various type of râles in the lungs. The recovery of these was all good, however, and the clinical data were not sufficient to warrant so specific a diagnosis as bronchitis.

Disregarding the contributory influence of the myocarditis and peritonitis in one case and the use of some ether in another, the postanæsthetic pulmonary morbidity of the major groups was found to be 0.42 per cent. No pulmonary complications followed the use of ethylene in the minor groups.

The most important complication referable to the gastro-intestinal tract is the nausea and vomiting. It occurs in variable degrees, of course, with all types of anæsthetics. In this series of

1,421 major operations, nausea and vomiting occurred in 563 cases, or in 39.6 per cent. The average number of times the patients vomited was 2.6 and the average duration of the nausea was 11.2 hours. Of the various types of operations, those on the gall bladder had the highest percentage of morbidity, 62.2 per cent of the 98 patients having nausea and vomiting over an average period of 18.1 hours. The average number of times vomiting occurred was 3.7. It is to be noted that of this group of 98 patients, 49 were given ether in variable amounts during the operation. The average duration of these operations was 61.6 minutes.

The duration of nausea and the number of times vomiting occurred varied with the various types of operations, as shown in Chart 2. As will be noted, the patients having thyroid operations were second to the gall-bladder cases in the percentage having nausea and vomiting. The duration, however, was not prolonged. It may be seen, also, that while the average duration of nausea with those having stomach operations was second to the gall-bladder cases with 17.6 hours, the number having nausea and vomiting constituted only 27 per cent of the total. The group in which the lowest percentage of nausea and vomiting occurred is a rather miscellaneous one including operations for herniæ, varicose veins, breast tumors, mastoid infections, pleural infections and other types of disorders which did not fall into any of the more distinct groups. With these, 21.5 per cent had an average duration of nausea of 7.1 hours and vomited two times as an average.

As will be noted the duration of the vomiting was seldom prolonged. The character of the vomiting was usually mild and rarely was it of a degree to result in any especial weakness or muscle soreness.

In the foregoing discussion, comparison of the relative values of ethylene and nitrous-oxide gases has purposely been avoided. Combinations of the latter with oxygen undoubtedly have a definite function to fulfill. As noted above, the use of ethylene is absolutely contra-indicated when the cautery is being used, when the X-ray or fluoroscopic machines are in use, etc. When gas is desired under these circumstances, nitrous oxide is of great value. The immeasurably greater margin of safety with the ethylene from the standpoint of the cardiac and respiratory mechanisms makes it by far the anæsthetic of choice. We feel that ethylene has all the advantages of nitrous oxide with the additional advantages of producing more adequate relaxation and at the same time of being much more safe even in the hands of the average good anæsthetist.

Mention should be made concerning the expense of using ethylene-oxygen anæsthesia. From the total time required for the 2,750 operations reviewed, it has been computed that the cost per minute is approximately 7½ cents or about 4½ dollars per hour. This cost, of course, is considerably greater than that of ether, but is about equal to the cost of nitrous-oxide-oxygen anæsthesia.

CONCLUSIONS

1. Combinations of ethylene and oxygen have added an extremely valuable and satisfactory anæsthetic medium to those already in use.

2. The explosibility of ethylene and oxygen is a real source of danger and precautions must be taken.

3. No excessive use of opiates is necessary to make possible satisfactory induction and anæsthetizing.

4. The induction and the regaining of consciousness are rapid, each requiring only a very few minutes.

5. The odor of ethylene is not a contra-indication to its use.

6. Satisfactory relaxation can be maintained with ethylene-oxygen in most instances.

7. The gas does not act as a cardiac or respiratory stimulant or depressant in amounts used for anæsthesia.

8. Blood pressure is not affected by the gas.

9. Bleeding in the wounds is not more than that ordinarily encountered.

10. Ethylene-oxygen is equally satisfactory for use with the very young or with the aged and is especially valuable with debilitated individuals.

11. Repeated use at frequent intervals does not decrease the potency of ethylene or increase the postanæsthetic nausea and vomiting.

12. The anæsthesia produced is equally satisfactory for minor surgery and major operations.

13. Postanæsthetic pulmonary complications are rare.

14. Postanæsthetic nausea and vomiting occurred with 39.6 per cent of major cases. Vomiting is usually mild and duration of nausea not prolonged.

15. It is believed that the margin of safety with ethylene as compared with nitrous oxide is very much greater.

16. Cost of ethylene-oxygen anæsthesia is about 7½ cents per minute.

We are indebted to Dr. R. D. McClure for his co-operation in the preparation of this report.

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RADIUM THERAPY IN SOME OCULAR CONDITIONS[1]

By WALTER SCOTT FRANKLIN, M.D., F.A.C.S., and FREDERICK C. CORDES, M.D., San Francisco, California

In addition to its use in malignant ocular conditions, radium has, in recent years, been applied to benign ocular lesions as well. There has been a lack of uniformity in the results obtained so that the value of radium in ophthalmology is still extremely doubtful in the minds of many.

As Lane[2] pointed out, much of the experimental work done on the use of radium in the region of the eye is of no practical value today because of the change in the types of screens, this change being the result of our increased knowledge of the effect of radium. There have been numerous clinical reports of its use in various ocular conditions. A review of these in most instances is of little value due to a lack of detail of the method employed. Important items such as the amount of radium, type of container, whether element or emanations, screening, type of applicator, distance, time, and details of application have often been omitted.

That radium has a definite place in ophthalmology there can be no doubt. As Lane states, more careful clinical reports must be presented in order that we may arrive at a better standard to serve as a guide in the treatment of various conditions.

We are presenting a few cases of ocular lesions treated with radium. While we realize that these cases are more or less isolated ones, the results have been definite enough to warrant the assumption that the effect obtained was due to the therapy applied. We hope this paper may stimulate more work with the detailed recording of the methods employed so that a better knowledge of radium therapy may be obtained.

We have been guided by the advice of Dr. L. R. Taussig, of the Department of Dermatology, as to the dosage and screening.

Only the positive findings have been noted in the following case reports.

CONJUNCTIVITIS

Case 1. Mrs. A. F. M., 67 years of age, had been under observation for 11 years with a persistent chronic conjunctivitis, the result of the cicatricial changes of a trachoma contracted in childhood. There was a definite conjunctival hypertrophy accompanied by dilated ocular blood vessels and mucopurulent discharge. Bacteriological examination showed staphylococcus in pure culture. All the usual therapeutic measures, including vaccines, had been tried with only mild relief from time to time. The patient had seen many oculists here and abroad without permanent improvement. December 14, 1925, radium was applied. Ten milligrams of the radium element in an 0.8 centimeter circular plaque screened by 0.5 millimeter silver and a piece of rubber dam was applied over the closed lids for 1 hour at a distance of 1 centimeter. The applicator used was the type described in our work on cataracts.[3] This was repeated twice a week to each eye for a period of 4 months. At the end of this time the condition was markedly improved. There was no discharge present and the lids had lost the thick puffy appearance they previously possessed. In addition, the ocular conjunctiva was now pale.

Case 2. Miss M. C., age 55, was seen in August, 1922, with a bilateral acute conjunctivitis that proved most resistant and developed into a chronic type with considerable hypertrophy and mucopurulent discharge. In addition, the bulbar blood vessels were markedly injected. After 6 months of unsuccessful treatment with the usual therapeutic agents the patient disappeared, to return in June, 1925. Treatment elsewhere had been of no avail and the condition remained the same. Radium was applied June 23, 1925, the method being identical with that of Case 1. After 6 months' therapy the condition had improved to such an extent that the conjunctivitis (including the bulbar) was practically normal.

VERNAL CONJUNCTIVITIS

Case 3. Lionel V. D., age 11, was referred by Dr. A. C. Macleish of Los Angeles, who felt the cooler climate of San Francisco would have a beneficial effect on the boy's case of aggravated vernal conjunctivitis. In addition to the use of copper sulphate and silver nitrate therapy, radium had been applied but was discontinued after a severe reaction. October 19, 1925, radium therapy was instituted twice a week to each eye, the dosage and method being identical with that in Case 1. The condition improved very materially the first 2 months, probably in part as a result of the change in climate. Following this the improvement was very slow. We advised a stronger dosage and on April 13, 1926, applied the above plaque of radium, screened only with rubber dam, directly to the everted lids for a period of 1 minute. Because of the size of the plaque, two applications were necessary to cover the entire lid. April 23 the other eye was similarly treated. On June 21, 1926, the same precedure was repeated on each eye. There was no acute reaction following this type of application. The patient returned to Los Angeles the latter part of June. On September 11, 1926, Dr. Macleish writes that "the lids are decidedly better than when he went to you but there are several nodules still present." The radium therapy will be continued under the direction of Dr. Macleish.

RECURRENT PTERYGIUM WITH HYPERTROPHY

Case 4. Mr. J. P., age 48, reported to the clinic October 10, 1925, with the following history. Twelve years previously a rapidly growing pterygium in the left eye was operated upon, and gradually recurred. The patient had

[2] Lane, Laura. J. Am. M. Ass., 1924, lxxxiii, 1838.

[3] Am. J. Ophthalmol., 1921, iv, June.

[1] From the Department of Ophthalmology, University of California Medical School.

been under the care of an oculist in Oakland who stated that he had subsequently operated upon the pterygium (transplantation) three times, only to have it recur persistently. The left eye showed nasally a pterygium composed of a raised nodular mass encroaching upon the cornea for about 2 millimeters. There was definite contraction of the conjunctiva; below and nasally was a symblepharon. Because of the size and the lobulated appearance, malignancy was considered a possibility. The small piece of tissue removed for examination was reported by Dr. Rusk, of the Department of Pathology, to show granulation tissue with no evidence of malignancy.

Radium was applied October 29, 1925, a 53 millicurie capillary tube screened only by a strip of adhesive being held directly to the pterygium for 4 minutes. Two weeks later the patient had a well defined radium reaction that subsided gradually and coincident with this the granulation tissue disappeared. At the time of the last examination, September 14, 1926, there was present only a retrogressive flat pterygium, the blood vessels being markedly contracted. In this particular case only one application of radium was deemed necessary.

CORNEAL MALIGNANCY

Case 5. Mrs. E. L. S., age 68, was seen May 7, 1925, and gave the history of observing a white spot on the right eye for the past few months that seemed to have grown slowly. It caused no symptoms. Examination showed in the cornea of the right eye an opaque roughly circular mass extending from the limbus to near the upper pupillary margin. The periphery appeared grayish white, flat and inactive, while the center was darker in color, finely lobulated, located in the adventitia and apparently extending to Descemet's membrane. From the limbus were both superficial and deep blood vessels extending into the growth. Diagnosis: Corneal malignancy.

On May 11, 1925, the eye was cocainized and 143.6 millicuries (emanations) in a small capillary tube screened with .5 millimeter silver and .5 aluminum was applied to the cornea over the mass for a period of 5 minutes. May 27 the mass seemed a little smaller. June 4, 1925, 264 millicuries were applied for 3 minutes, the same screening being used. June 25, the emanations not being available, a 10 milligram plaque (same as in Case 1) screened with .1 millimeter aluminum and rubber dam was applied for 5 minutes. This was repeated July 22. The tumor mass was now half its original size and the blood vessels definitely smaller. The dosage given June 25 was repeated August 12 and again September 2. October 6, 135 millicuries screened only by a piece of adhesive were applied directly to the cornea for 2 minutes. This application was followed by a mild local reaction. The corneal process gradually subsided so that by January 6, 1926, only a flat scar remained in which there were several small areas that gave the appearance of calcification. The blood vessels were now barely visible. Subsequent observation has shown no change in the condition.

COMMENTS

The cases here reported are all of the type that were resistant to the usual therapy, the type that frequently is a source of chagrin to the oculist, when, after extensive treatment, the condition remains unaltered. It is in this variety particularly that the possibility of radium therapy should be kept in mind.

In the conjunctival cases the desired result was obtained with much milder doses, that is at a greater distance and with more screening, than those used in the vernal conjunctivitis, the pterygium, or the corneal malignancy. Another factor to be observed is that the dosage, which with very little screening was applied directly to the everted lids, did not produce a reaction in vernal catarrh, but in the pterygium with its granulation tissue amount produced a reaction. In the corneal malignancy the application of radium made unnecessary the enucleation of an eye that had .8 of normal vision before and after treatment. In this particular instance it seemed the only available therapy.

An interesting observation has been called to our attention numerous times during the application of radium, particularly during the work on incipient cataracts in which a large series of cases was under treatment. Patients frequently commented upon the fact that indefinite neuralgia-like pains that had been present about the eyes and temples disappeared after a few applications of radium. We merely present this observation without attempting its explanation.

SHORTENING OF BONES OF THE LEG TO CORRECT INEQUALITY OF LENGTH

By JOHN A. BROOKE, M.D., Philadelphia

FOR more than half a century, surgeons have considered it feasible, in certain cases, to correct inequality of leg length by operative procedure. The early attempts to correct this asymmetry were those of shortening the normal leg rather than to lengthen the short limb. Successful operations of lengthening shortened legs have only been performed during the past few years since the development of aseptic bone surgery. Which of these two procedures is the most advisable to follow, would depend somewhat upon the patient's height: If the individual is nearly 6 feet tall, and especially if it be a woman, one could unhesitatingly recommend a shortening of the bones of the normal leg; but on the contrary if the height is but 5 feet 5 or under, one would be slow to suggest further shortening of 2, 3, or more inches.

The operative lengthening of the femur is a decidedly major operation attended by tremendous shock and by much trauma of soft tissues favoring infection; the cases selected must of necessity be only the young and vigorous.

Schede and also von Eiselsberg, nearly 20 years ago, resorted to a zig-zag osteotomy with strong postoperative traction to gain the required length. No report of these cases is obtainable but the method was apparently not of sufficient success to be generally followed.

Codivilla described lengthening of the extremity by a method which was the first application of a steel pin through bone.

P. B. Magnuson[1] in an article entitled "Lengthening Shortened Bones of Leg by Operation," gives the results of his experiments on dogs. This report is one of the first published in accordance with our present views on bone surgery. He gives his indications for the operation and states that the vessels and nerves stand the stretching process to a considerable degree. A Z-shaped osteotomy was done, traction applied for several minutes, and the lengthening obtained was maintained by ivory screws inserted through holes drilled, then threaded. The ivory screws are absorbed and do not act as a foreign body.

In 1916 R. Tunstall Taylor[2] reported a case of lengthening of the femur in a girl of fifteen. His method was similar to that described by Magnuson. He used bone pegs instead if ivory screws.

V. Putti,[3] in 1921, gives his method of lengthening the femur. He does a Z-shaped osteotomy with a motor saw. The traction force for stretching the soft tissues is obtained by his osteotome which is a telescoping tube, screwing in or out and is attached to pins fixed in both proximal and distal ends of the bone. The force is powerful and is applied directly to the skeleton and increased from day to day. He reports operations upon ten cases by this procedure and in some cases an integral lengthening of more than 3 inches.

I am sure that such results as obtained by Putti can be accomplished only by one having unusual skill and masterful technique, and unless we are sure of an appreciable lengthening by this operation, which is a severe one, we are not justified in recommending it to the patient. For the average surgeon operative shortening of the opposite femur, when this is found advisable, should be the choice. It is simpler, much less dangerous, and decidedly accurate, for shortening can be figured to one-eighth of an inch.

The earliest report of operative shortening of the femur was by Sayre in 1863. The method used was an osteotomy allowing the fragments to override. This same procedure with a transverse or oblique osteotomy or a resection of a portion of the shaft without internal fixation of fragments was followed until a rather recent date.

In 1908, P. Glaessner[4] reported three cases of shortening of the femur treated in Hoffa's clinic by oblique osteotomy and continuity resection:

> The first was an old intracapsular fracture of the neck of the femur. Operation, oblique osteotomy of sound femur, bones over-riding until legs were of equal length. Good recovery but shortening is still noticeable.
>
> A second case was a congenital hip dislocation. The same operation was done as Case 1. The gait was improved. No mention is made of improvement in leg length.
>
> The third case was a fracture of the femur. Operation consisted of resection of a portion of the shaft, and coaptation of bone ends by silver wire. Result was good; legs are equal in length.

Heine's[5] method was similar but he states that the result is uncertain because bone suture does

[1] Surg., Gynec. & Obst., 1913.
[2] Am. J. Orthop. Surg., 1916.
[3] J. Am. M. Ass., 1921, Sept.
[4] Ztschr. f. orthop. Chir., 1908.
[5] Ztschr. f. orthop. Chir.

not sufficiently fix the bone and dislocation may occur.

Deutschlaender's modification of Heine's operation was to add an aluminum splint and screws to hold bone ends in apposition.

More recently Calvé, Ducing, Uteau, and Tunstall Taylor have suggested new procedures for compensatory shortening of the unaffected femur.

Calvé[1] describes three ingenious procedures: (1) auto-pegging, (2) that by tenon and mortise, (3) by direct holding (dovetailing).

The method of auto-pegging is the easiest to perform and is recommended because of its simplicity. The second procedure, that by tenon and mortise, gives better end-to-end apposition and a good alinement but is a more delicate operation. The third method suggested is dovetailing or direct holding. This method is mechanically perfect and prevents anteroposterior as well as lateral displacement. Calvé states that this is difficult of execution and that the method had better not be employed. His first procedure, auto-pegging, which seems very practical, consists of an oblique section of the femur in the middle third. From the upper part of the lower fragment, a quadrangular tenon is cut out with an electric saw. The tenon is inserted into the medullary canal of the upper fragment. The oblique surfaces tend to slip one on the other, the tenon is wedged up and limits the ascent of the lower fragment. Angular displacement of the lower fragment is impossible. The shortening is equal to the length of the tenon plus the thickness of the compact bone—the cortex to the medullary canal. In this procedure the line of force is preserved and the functional result excellent.

The methods advised by Calvé show a distinct advance in bone surgery and stand for mathematical certainty and exactness in length.

The procedures mentioned above for lengthening, as well as shortening the limbs, have dealt entirely with operations upon the femur. From its length and the character of the muscles attached this bone lends itself more readily to either operation.

In a fairly complete survey of the surgical literature of the past 50 years, I have been unable to find the report of a case in which the tibia and fibula have been shortened to correct the disproportion in leg length. The first case to be discussed in this article is that of a professional skater, a young man, age 28, who has given exhibitions of his skill in most of the large cities of the United States and Canada.

[1] Am. J. Orthop. Surg., 1918, April.

In December, 1919, while performing his act he fell and fractured both bones of his right leg. He was treated in a local hospital for some weeks and the end-result was a firm union of the bones of the leg, but consolidation had taken place with a full inch or more of shortening. He walked with a slight limp but got around very well. On attempting his fancy skating he found he was handicapped. He was unable to perform certain glides, the spread eagle, and many of his intricate figures that required his knees to be on an even plane. Realizing that his skill was now greatly hampered, he sought advice in regard to operative lengthening of his shortened leg. Different surgeons consulted, felt that no definite promise could be given as to the length gained by operation. The idea was then abandoned but the suggestion that the opposite leg be shortened to bring the knees on the same level forcibly appealed to the patient and the following operative procedure was followed out in January 1921.

The usual incision of 6 or 7 inches, as for a tibial graft, was made over the middle third of the normal tibia. With the aid of a small metal ruler an area, 5 inches long and ½ inch wide, was outlined on the flat surface of the tibia. This piece of bone was removed by a motor saw by means of a single blade and the cut was made somewhat at an angle (Fig. 1), the cortex being broader than the medullary portion (Fig. 1, a and b). The object was to prevent this tongue of bone from dropping into the medullary canal when it was later placed in the slot at the tibial ends after the shortening had been done. About the middle of the tibia, a cylinder of bone, the required length to be shortened, was removed by using the gigli saw posteriorly and the motor saw for the anterior portion (Fig. 2,b). Through an incision over the external border of the leg, the fibula was exposed at about the same level as for the tibia and a similar piece to that taken from the tibia was removed from the fibula (Fig. 2,a). The fibula was cut obliquely, the ends quickly came together, and were held in end-to-end apposition by kangaroo tendon through drill holes (Fig. 3). The cut ends of the tibia were held together by fitting the wedge of bone into the bed from which it was taken and holding it there by kangaroo tendon through drill holes in the side of the slot and over the inlay as is usually done in the bone graft procedure, as suggested by Albee (Fig. 3). It was, of course, necessary to shorten this long wedge of bone (Fig. 1,b) so that it would nicely fit as a key in the slot. This held the ends of the tibia in perfect apposition and alinement. Their same relative positions were maintained without any chance for rotation of the lower fragment. An additional reason for using the graft was its osteogenetic power, as it gives earlier bone production and consolidation.

Healing was by first intention; immobilization in plaster-of-Paris was carried out for 8 weeks. For 2 weeks more some weight bearing was permitted with plaster splint. For the 2 months following, a double upright brace coming just below the knee was used to prevent any possible bowing at the point of union. Callus formation was slow. The roentgenograms showed only slight callus formation at 8 weeks. Consolidation was complete in 4 months.

In about 10 months, this patient had resumed his old profession (exhibition skating) and in a year was doing his most difficult stunts with his old time skill and daring; performing his intricate figures as well, if not better, than before his injury. He has since given exhibitions of his skill in many of the foreign capitals.

We realize that in this case the shortening of the leg was only a small amount, 1 inch. Considering this, were we justified in subjecting the

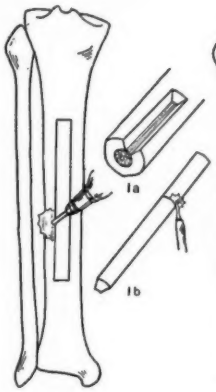

Fig. 1.

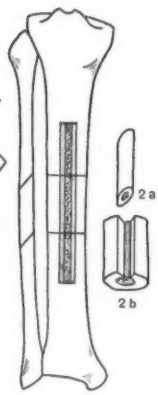

Fig. 2.

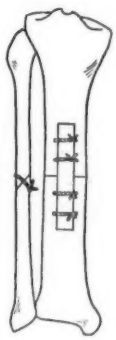

Fig. 3.

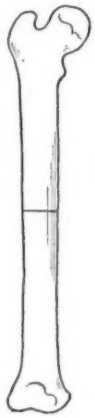

Fig. 4.

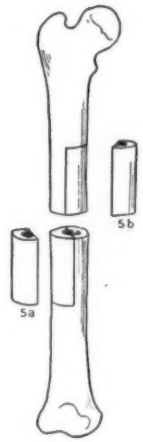

Fig. 5.

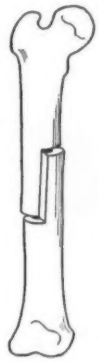

Fig. 6.

Fig. 7.

patient to operative risk for correction of the deformity? Ordinarily not, but in this instance equality in leg length had to be obtained or the patient must give up his vocation.

The two most evident dangers of the procedure were: first, infection; second, non-union. With the modern bone technique the first danger was reduced to a minimum. Non-union occasionally occurs in fractures of the tibia in its lower third, rarely in its middle third. The chief nutrient artery of the tibia enters the shaft posteriorly in its upper third just below the oblique line and is directed obliquely downward. It would consequently be cut off by fracture or bone section of the middle or lower third. The additional blood supply entering the tibia from the periosteum is apparently sufficient for bone repair after most fractures of the middle third.

E. L. Eliason[1] had made an investigation of the blood supply in the lower third of the tibia. With reference to its bearing on cases of non-union of fractures of this region, he points out that the anterior tibial artery is the source of the greater proportion of the blood supply to the lower end of the tibia. The artery lies immediately against the tibia with no intervening muscle protection. This position exposes it to injury from bone fragments in fractures; thrombosis, or even laceration of vessel wall may result. The arterial anastomosis of the ankle and foot is a rich one, nevertheless, the lower end of the tibia comes in for a very small part of it.

With ordinary care and especially when the operative shortening is of the middle third of the tibia we may conclude, that the danger of non-union is very slight indeed; that the method outlined above can be recommended because the operation presents no technical difficulties, and because there is a mathematical certainty to the shortening. We feel that the tibia and fibula could, with safety, be shortened 2½ inches. Beyond that point there may be some question as to the muscle and tendon slack interfering with full power and there would also be an unsightly disproportion between the length of the thigh and the leg. The most advisable place for shortening is the middle third.

Since the case cited above and operated upon in January, 1921, we have used the same procedure to secure equal leg length in a case of residual paralysis of anterior poliomyelitis, a shortening of a little more than 2 inches being done on tibia and fibula of the unaffected leg.

Shortening of the femur is an operation more frequently called for, and we do not hesitate to advise it in suitable cases. The indications for its use are found in those of more than 1½ inches shortening, the result of congenital abnormalities, bone disease with destruction, and fractures with overriding.

The method we have employed is as shown in Figures 4, 5, 6, and 7. The ordinary step method of shortening is used: The shaft of the femur is reached through an incision on the outer side of thigh 6, 7 or 8 inches in length, the length of the incision being governed by the amount of shortening required. The fibers of the vastus externus are separated, the vastus intermedius is incised; the femur is bared but care is exercised not to denude the bone of its periosteum. A broad pliable strip of metal is passed back of the femur

[1] Surg., Gynec. & Obst., 1921, Nov.

and is used as a guard to protect the soft structures. A rotary bone saw, with a large blade, is used to cut through the femur transversely. This is done about the middle of the shaft (Fig. 4).

In a femur of large caliber it is usually necessary to use a gigli saw to complete the section at its posterior and inner part. The proximal and distal portions may then in turn be readily brought through the incision and cut longitudinally by the motor saw the required distance to be shortened; the saw making the cut in an anteroposterior plane. One half the shaft is removed from the proximal fragment (Fig. 5,b), the other half from the distal fragment (Fig. 5,a). The cut ends are fitted together (Fig. 6) and held in position by a bone clamp while two holes are drilled in each fragment and then threaded with a tap for beef bone screws, which maintain the cut ends in firm apposition (Fig. 7)

It is necessary to have the bone screws of sufficient length to go through the cortex from side to side. In our first case the screws were too short and pulled away from the cortex on the inner side, necessitating the use of the Parham band to maintain apposition. Union in these cases takes place in about the same time as it does in the average fracture case with open reduction. There are no technical difficulties with this method and the amount of shortening can be exactly determined.

We cannot quite agree with Steindler in his recent excellent work *Operative Orthopedics* (pages 174 and 176) in which he states: "For practical purposes a simple osteotomy with subsequent gliding of the fragments toward each other is a simpler, shorter, and equally effective procedure provided that immobilization during and following operation is carried out correctly." We find that the overriding is hard to control at a definite point and that much of the exactness of the shortening procedure is lost, if we do not measure carefully and use some method of fixation directly to the bone.

The surgical risk in these operative procedures outlined is not great. In many cases, especially in young individuals, it is very desirable to restore a common level to both sides of the pelvis and eliminate the use of an elevated shoe.

EDITORIALS

SURGERY, GYNECOLOGY AND OBSTETRICS

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WILLIAM J. MAYO, M.D.....Chief of Editorial Staff

MAY, 1927

THE VALUE TO THE SURGEON OF THE SENSE OF SMELL

NINETY-FIVE per cent of man's information is obtained either directly by visual means, or indirectly through visual training of the other senses.

The cerebrum is the ganglion of all distance receptors and is the seat of the intellectual functions. The primitive cerebrum of the vertebrates was developed from the olfactory ganglion. The great expansion of the cerebral cortex in the higher mammals, and especially man, is dominated by visual necessities and controls consciousness, while the sense of smell has become less important. The neopallium, that great portion of the brain which had its origin outside the olfactory ganglion, is the mechanism which carries on vital processes.

The two most important steps in man's elevation above the brute were (1) co-ordination of the growth of the cerebral cortex with the development of the sense of sight, and (2) the assumption of the upright position which freed the hands for training through the sense of sight. Only man and some of the higher mammals have achieved direct communication between the sense of sight and the cerebrum.

In lower animals all the senses, with the exception of the sense of smell, are relayed, so to speak, through various ganglia before reaching the cerebral cortex with all the possibilities of confusion and misinterpretation which this method entails. In them the sense of smell is dominant over all the other special senses, including vision, and controls behavior, but it gives no estimation of time, space, or motion.

The sense of smell is dependent on bundles of olfactory nerve cells, each of which ends in a hair; at the base of the bundle are pigmented cells. Just what the use of the hair endings is in the sense of smell we have no means of knowing positively, but our knowledge of the antennæ of the radio, little as it is, leads us to believe that electronic vibrations of colloids and unstably oxidized molecular bodies coming into contact with these areas are recognized as odors either by their size or their rate of speed, just as length and speed of rays of refracted light are recognized by the eye as colors. It is probable that the pigmented cells at the base of the olfactory bundle are necessary to transmit impression of odor to the cerebral convolutions where they are recognized. Albino animals have no sense of smell and are sent to the butcher because eventually they would die from eating poisonous material indiscriminately.

In the nasal cavity of man there is only about one square inch of olfactory pigmented cells, a very small amount as contrasted with that of many of the lower animals, who have a more highly developed sense of smell. The

hound has an extraordinarily well developed sense of smell. He follows the scent until he determines the probable site of the quarry, and depends on inefficient sight only for its final location. The relative unimportance of the sense of smell to man can be readily noted by the size of the olfactory ganglion as compared with the total volume of the brain. Small as the olfactory ganglion in man is, however, the sense of smell is an extraordinarily delicate means of direct communication with consciousness and enables many gases and vapors to be recognized by their odors in such minute dilution as to be wholly unrecognizable by any form of scientific apparatus. When the sense of smell is trained it gives immediate information of many conditions, recognition of which by the other special senses would be slow and often inaccurate.

The surgeon in passing through his wards, if he has given thought to training the sense of smell, can recognize readily many abnormal conditions by this means. The characteristic odor of a fistula in the cæcum, for instance, is easily distinguished from that of a fistula in the sigmoid, rectum, ileum, or jejunum. In the days when typhoid fever was common, a good clinician would make a presumptive diagnosis of typhoid fever from the sense of smell. Diphtheria in the old days was recognized by the odor, and many conditions of the stomach can be determined by the odor of the eructated gases. Certain poisons have characteristic odors which make possible speedy identification and use of the proper antidotes. In the ancient civilization, perfumes, oils, and incense of pleasing odors were sent to the guest as the greatest mark of courtesy that could be shown. Many fragrant or pungent herbs were supposed to have an influence on health. The basis for this belief lies in the fact that sunlight causes various plants to excrete ozone. Most qualities that are spoken of as flavors are recognized through the sense of smell; without the sense of smell the sense of taste could not distinguish an onion from an apple.

W. J. Mayo.

IMPORTANCE OF EARLY ASSUMPTION OF FUNCTION IN RECONSTRUCTIVE SURGERY

INTEREST in reconstructive surgery has increased during recent years, and surgeons are more and more thinking in terms of function. As a result, many of the ideas which formerly prevailed, have been abandoned. This statement applies particularly to the suturing of tendons and nerves. If the statistics of tendon sutures compiled as recently as twenty years ago are examined, one will be convinced that the results are not as good as they should have been.

Some of the imperfect results were due to too long immobilization. Adhesions formed which could not be overcome. A tendon suture must permit of early function and must not strangulate the tendon. The Frisch suture, which begins well back of the line of division and merely grasps the tendon at three points on each side, gives sufficient purchase on the tendon to allow of early motion. It does not strangulate. The cut surfaces of the tendon may be accurately approximated by interrupted catgut sutures. When such a suture is applied, the tendon may be used as soon as the patient desires. Motion is usually prevented for about 48 hours, because of pain which results from attempts at motion.

When the tendon is surrounded by a synovial sheath, the possibility of late separation at the suture line should be borne in mind. Tendon does not repair entirely from tendon cells—the epitenon and peritenon take an important part in repair, and when the

tendon is surrounded by a synovial sheath, the repair may be delayed somewhat.

In case of division of a peripheral nerve, a primary nerve suture should always be attempted. Contused and crushed portions of the nerve should be removed until normal funiculi herniate from the ends. One of the most important things in nerve surgery is to restore the nerve pattern. The segments of the nerves should not be rotated. They should be fixed by two stay sutures placed at corresponding points of the segments, so that no rotation—thus causing distortion of the nerve pattern—can occur. This is, however, merely good surgery in which an attempt is made to restore as nearly as possible normal anatomical relations. The epineurium should be completely closed, for if developing neurofibrillæ stray into the surrounding tissues a dense scar may form which will seriously interfere with nerve repair.

Early use of muscles is desirable in such cases, and for this reason an elastic apparatus is preferable to rigid splinting in maintaining the neutral or slightly overcorrected position.

Early assumption of function is the *sine qua non* in the two types of reconstructive surgery mentioned above. DEAN LEWIS.

MASTER SURGEONS OF AMERICA

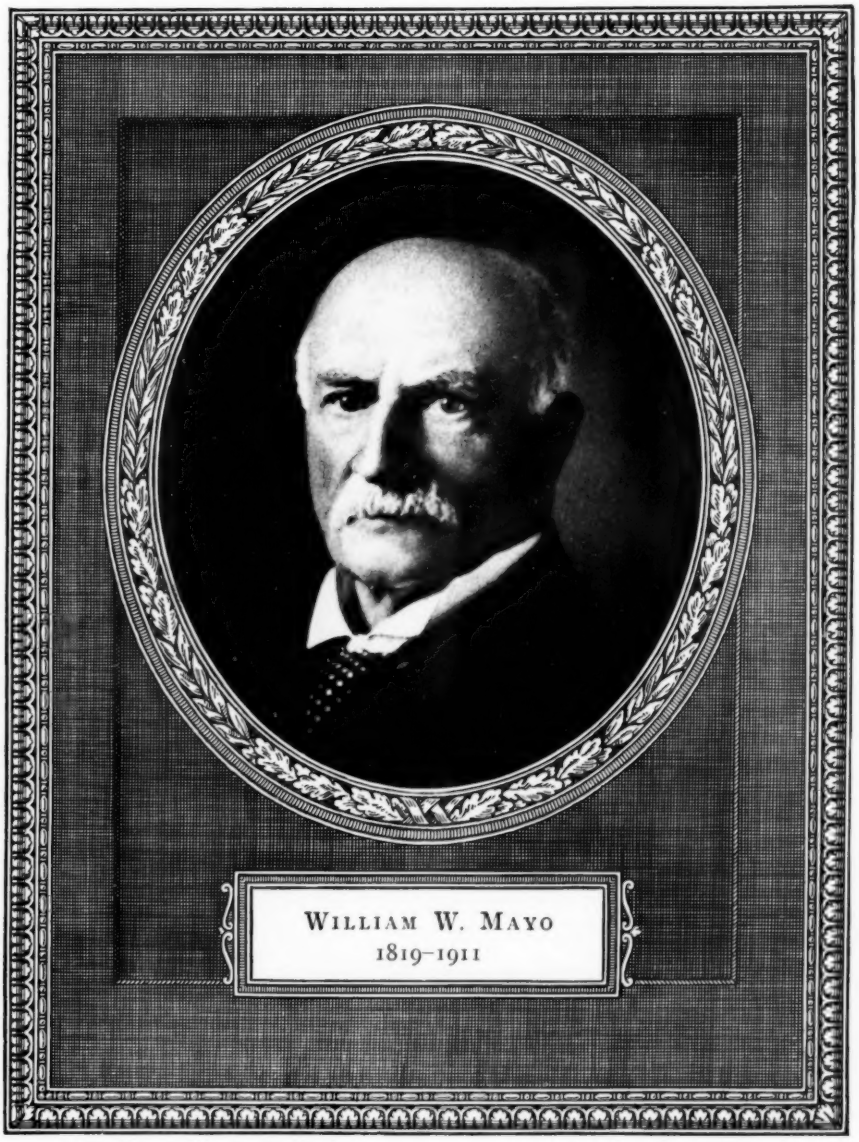
WILLIAM WORRELL MAYO

A Pioneer Surgeon of the Northwest

WILLIAM WORRELL MAYO was born May 31, 1819, in Manchester, England. He came from a family with 200 years of scholarly traditions. Many of the Mayos had been physicians. John Mayo (1643–1679) was one of the first of the physician chemists whose combined studies led to the discovery of oxygen. John Mayo (1761–1818) was a Fellow of the Royal College of Physicians of England, Harveian lecturer in that college in 1795, and physician of Middlesex Hospital from 1788 to 1803. Paggen-William Mayo (1766–1836) was a Fellow of the Royal College of Physicians, Galtonian lecturer in 1788, Harveian lecturer in 1807, and physician to the Middlesex Hospital from 1793. Charles Mayo (1788–1876) completed his medical studies at St. Bartholomew's Hospital in 1810, became a member of the Royal College of Surgeons in 1811, and a Fellow of that college in 1843. He was chief surgeon of the hospital at Winchester, England, from 1811 for more than fifty years. Thomas Mayo (1790–1871) was a Fellow of the Royal Society, Fellow of the Royal College of Physicians, member of the Staff of Middlesex Hospital for many years and for five years President of the Royal College of Physicians of England. Herbert Mayo (1796–1852), a brother of Thomas, was a Fellow of the Royal Society, Fellow of the Royal College of Surgeons, Hunterian professor of anatomy at the Royal College of Surgeons from 1828 to 1829 and professor of anatomy and physiology of King's College from 1830 to 1836. In the latter year he was one of the founders of the Middlesex Hospital Medical School. He did much original and sound work in the elucidation of the physiology of the fifth and seventh cranial nerves.

William Worrell Mayo received his early education at Owens College, now the University of Manchester, where he was a pupil and protégé of the famous physicist, John Dalton. His special college training was in physics and chemistry.

When Mr. Mayo was twenty-six years of age, in 1845, he came to New York City where he remained for two years in the practice of chemistry, and served as instructor in chemistry and physics in the Bellevue Medical College. In 1847 he removed to Lafayette, Indiana, where he studied medicine with Dr. Eleazer Deming as his preceptor for two years. In 1849 he went to St. Louis where he continued to work in chemistry while completing his medical studies in the



WILLIAM W. MAYO
1819–1911

UNIV. OF MICH.

University of Missouri. Here, in 1851, he married Louise Abigail Wright, a New York girl of Scotch parentage, born December 23, 1825. Here he was an assistant to Professor John Hodges. He received his medical degree from the University of Missouri in 1854.

After obtaining his medical degree he returned to La Porte, Indiana, and began the practice of medicine. At that time it was generally believed that La Porte would become the great city into which Chicago eventually developed. Indeed, Dr. Mayo and Dr. William Byford, later of Chicago, had such faith in the ultimate development of La Porte that they started a medical school in that city in the fall of 1854. During the first term the building and equipment burned and they were never replaced.

Early in the spring of 1855 Dr. Mayo with his family consisting of his wife and two daughters drove across the country to Galena, Illinois, and from there traveled by steamboat to St. Paul, Minnesota. The reasons for this move may, no doubt, be found in the comparative reputations of Indiana and Minnesota from a climatic standpoint and to the boom which was then in progress in Minnesota. There was much malaria in Indiana around La Porte. Minnesota was known to be free from it. Minnesota also, for many years, had been considered to have so healthful a climate that it was "a good place for the cure of consumption." But no doubt the principal reason for Dr. Mayo's trying his fortune in the new territory of Minnesota was because of the unprecedented immigration to that state in the spring of 1855.

It is impossible to understand the fortunes and misfortunes of the next ten years of Dr. Mayo's life without some appreciation of the conditions in Minnesota[1] during the period.

On March 4, 1849, the thirtieth Congress of the United States passed a bill organizing the territory of Minnesota. The news did not reach St. Paul until April 9 when it was brought up the river by the first steamer of spring.

When the newly commissioned governor, Alexander Ramsey, a resident of Pennsylvania, was preparing his journey to the territory, so little was known east of the Alleghenies of Minnesota that his neighbors inquired whether he would reach it by way of the Isthmus of Panama or whether he would have to sail around the Horn. Governor Ramsey reached Mendota, Minnesota, May 27, 1849, and a month later, his residence at the capital of St. Paul having been erected in the meantime, he and his family were transported there together with all of his belongings in a birchbark canoe. St. Paul in the winter of 1848–1849 consisted of about one dozen frame houses not all completed and eight or ten small log buildings with bark roofs. By the time the governor arrived, there were about 150 buildings including those in various stages of erection. In July, 1849, the total white population of St. Paul was listed as 910 and the total population of

[1] The facts concerning conditions in Minnesota are from Folwell's *A History of Minnesota*, vol. i. Minnesota Historical Society, St. Paul, 1921.

the territory as 4,131. The number of Indians in the territory was estimated at about 25,000. Mail was received only once a week by way of Prairie du Chien.

The white population was confined to a small triangle of land between the St. Croix and Mississippi rivers. This small group of settlers lived in the most primitive of pioneer manner. But the bulk of them were honest and God-fearing. The first territorial legislature in 1849 passed an act to establish and maintain common schools. Another act forbade the sale or giving of liquor to Indians; another established the liquor license system. A very stringent Sabbath law was passed. The second legislative session of 1851 passed a bill to incorporate the University of Minnesota. In 1850 a steamboat with very light draft proceeded up the Minnesota River into the rich agricultural territory to the west of the Mississippi. The possibilities of this country were well known to the settlers and now that the navigability of the Minnesota was demonstrated, agitation was begun to purchase the land west of the Mississippi from the Sioux. This was done by the treaty of Traverse des Sioux which was signed July 23, 1851, and ratified by Congress June 23, 1852.

About the only products which the United States east of Chicago had ever seen from Minnesota were furs, cranberries, and ginseng. The settlers were, however, raising excellent grains and vegetables and by Herculean effort in 1853 contrived to send to the great exposition in New York City an exhibit of their agricultural products. These were so good that they greatly surprised the eastern seaboard and turned marked attention to the new territory of Minnesota. The next year the track of the Chicago & Rock Island Railroad was completed into Rock Island on the east bank of the Mississippi. This was deemed so important an event that it was celebrated by a steamboat excursion to St. Paul. It was thus demonstrated that, when navigation was open, St. Paul was within thirty hours' mail service to Chicago and four days to Washington.

With the opening of navigation, April 17, 1855, the first steamboat to St. Paul brought 814 passengers. Dr. Mayo and his family were among these. It was estimated that there were 40,000 people in the territory at the close of 1855. They came in largest numbers from the state of New York, then from Ohio, Indiana, and Illinois and from New England. They built log houses for dwellings and for schools.

But these pioneers were young, hardy adults who had come to a new country to seek their fortunes. They were widely distributed over undeveloped territory. They were not prone to sickness and had no time to imagine ills. Even when really sick, lack of transportation made it necessary for them to cultivate their own medical resources.

Such a country was no place for a young doctor to prosper in his profession and Dr. Mayo, after establishing his family in St. Paul, was, no doubt, glad to accept a position with the Northwest Exploring Company on an expedition to

the northern part of the territory. While on this trip he filed a claim on some land opposite the Bay of St. Louis in Minnesota, near the present site of Duluth. He was appointed by the territorial governor chairman of the first Board of County Commissioners of St. Louis County and while holding this office located the county seat at a point where the city of Duluth is now built. Dr. Mayo was also appointed by the governor to take the 1855 census in St. Louis County. After completing this and after having his land claim successfully "jumped," he started to return to St. Paul with the Exploring Company. One night a sudden change in the wind sent the blaze from their camp fire into the needles of the fir trees and almost instantly the camp was on fire. All the provisions of the camp were burned. The men themselves barely escaped with their lives. Their compasses and guns having been burned, they lost their way and were five days in the woods without food. One of the party became insane and died. The others finally reached St. Paul.

In the year 1855 there were 119 steamboat arrivals in St. Paul from up the Minnesota River. This meant that there was already a very considerable settlement in the rich agricultural lands lying on this river. Among others the town of Le Sueur seemed to give promise of great development. An almost successful effort was made in 1856 and 1857 to transfer the territorial capital from St. Paul to St. Peter near Le Sueur. In the spring of 1856 Dr. Mayo removed with his family to a farm across the river from Le Sueur. The following spring he removed to the village itself. Here he engaged in the practice of medicine but this was not nearly sufficient to require his whole time and he became interested in a small steamer on the Minnesota River. It is worthy of note that at the same time Mr. J. J. Hill, afterward the great railway genius of the Northwest, was also engaged in steamboating on the Minnesota. He and Dr. Mayo then and there began a friendship which continued throughout their lives.

But the land boom of the territory of Minnesota which had progressed until town lots had been sold at from $1,500 to $2,000 each in wholly undeveloped town sites, and which at no time was greater than in the spring and summer of 1857, was doomed to collapse. On August 24, 1857, the Ohio Life Insurance and Trust Company of New York failed. Before sundown there were suspensions and failures in every considerable town in the United States. The panic struck Minnesota with extreme violence. Everybody was in debt and the territory was literally emptied of money. Business ceased; banks closed their doors, merchants suspended or assigned; city lots became virtually valueless. Thousands who believed themselves wealthy soon found themselves in actual bodily need. The population of St. Paul fell off almost 50 per cent.

Of Dr. Mayo's life during the next five years little record remains. It was, no doubt, that of the frontier physician among a people whose illnesses were largely those of the communicable diseases of childhood, the conditions incident

to child-bearing, and the accidents associated with rough frontier life. It must be kept in mind that the people of the community during this period were, for the most part, young, healthy adults, thriving on plentiful food and fresh air, but because of the panic of 1857 and the distance from market, having very little money even for the necessities let alone the "luxuries" of illness. And then came the Civil War.

In the summer of 1862 the Sioux Indians seized the opportunity afforded them by the absence at war of most of the male members of the population to attempt to recover their lands from the white settlers. A general uprising and massacre of the whites occurred in the vicinity of New Ulm, which was the rallying point of resistance of the settlers. Dr. Mayo, then forty-three years of age, accompanied a relief force to New Ulm as surgeon. Shortly after this he received his appointment as provost surgeon for southern Minnesota in charge of recruiting stations for the Civil War. Early in the spring of 1863 he moved with his family to Rochester, Minnesota, as a more advantageous point for recruiting.

Rochester (population 2,663 in 1865) was in every respect a much better town than Le Sueur. Recognizing this soon after coming to Rochester, Dr. Mayo bought land and established a home on the ground on which the Mayo Clinic Building now stands. In addition to his draft board duties, he rapidly became the leading physician and surgeon of Olmsted County. As an evidence of his continued scientific interest, when in December, 1863, a number of Indians convicted of massacring whites in the vicinity of New Ulm a year previously were hanged, Dr. Mayo obtained possession of the body of one of them, Split Nose. He carefully dissected the body, cleaned and articulated the skeleton, which he later used for teaching osteology to his two sons, William J. and Charles H. Mayo. By 1871 he had prospered sufficiently so that he felt he could afford to take a postgraduate course in medicine in the Bellevue Hospital in New York.

Dr. Mayo was one of the first physicians in the West to invoke the aid of the microscope in medical work and to become expert in its use. While his sons were still in high school, about 1878 (?), he even mortgaged his home in order to get money to buy a new and improved microscope. This incident also sheds light on another phase of his character. With all his wonderful ability as a physician and surgeon and his extensive practice which kept him going almost night and day, he was a notoriously poor collector of fees. Indeed, his old driver and henchman, Jay Neville, used to grow quite profane at times over remembrances of the Doctor's failure to make his patients pay up. Like all frontier practitioners of that day, he had done a large share of emergency surgery since coming to Minnesota. In 1871, he performed his first laparotomy for ovarian tumor. The patient was a woman, aged forty-six, wife of a blacksmith, who, under Dr. Mayo's instruction made some of the instruments with which the operation was performed. During the next thirteen years he performed thirty-six similar operations.

July 21, 1883, a cyclone passed over the northern portion of the town of Rochester, destroying the lives of twenty-two persons and injuring many others. Dr. William W. Mayo was appointed by the City Council to take charge of a hospital improvised for the injured. Assistance in nursing was rendered not only by townspeople but also by Sisters from the Convent of the Sisters of St. Francis in Rochester. The catastrophe not only demonstrated the need of a hospital in the town but also suggested to the Sisters the desirability of their providing one. Some weeks later, after the injured persons had been relieved and the temporary hospital closed, Mother Alfred, the Mother Superior of the Community, approached Dr. Mayo with the proposition that they would erect a hospital provided he would take charge of it. Accordingly, in the spring of 1885 Dr. Mayo purchased for the Sisters a tract of fourteen acres of land, consisting of an orchard farm, on the western edge of the town, one mile from the post office. After various delays a hospital of forty beds, the original St. Mary's, was erected and equipped.

Dr. Mayo was indefatigable in his work. Besides his regular town and country practice he had a large consulting practice. He drove fine horses, kept rigid office hours from 11 to 12 in the morning, 1:30 to 3 in the afternoon, and from 7 to 8 in the evening, and only an important emergency was allowed to interfere with this routine. Outside of their school hours he took with him on his rounds his two sons, William and Charles. They also assisted him as much as they could in the office and at postmortem examinations, sometimes sitting on the table or standing on boxes to get a better view of what was being done. When the boys were sixteen and twelve years of age respectively they assisted their father at operations. Thus the father and two boys became a surgical family.

Dr. William Worrell Mayo was one of the founders of the Minnesota State Medical Society in 1868, and its president in 1873. In 1882 he organized the Olmsted County Medical Society and was a member of it during the remainder of his life. He was a member of the American Medical Association for nearly fifty years. He made numerous contributions to medical literature on various medical and surgical topics.

Politically Dr. Mayo was a liberal Democrat, and though living in a Republican state and community he was elected Mayor of Rochester several times and twice State Senator. He always took great interest in governmental affairs, municipal, state, and national. He loved to travel and when his sons gradually relieved him of the burden of his surgical practice, he made two trips around the world, the last one when he was 87 years of age. On this trip he was absent seven months and so hale and hearty was he that no one questioned his being too old to take the trip alone.

Dr. William Worrell Mayo died in Rochester, Minnesota, March 6, 1911, following an illness which was the result of an accident.

When we attempt to sum up the incidents in the life of Dr. William Worrell Mayo, we are struck by the fact that here was a man who had inherited excellent family traditions from the scientific standpoint, whose personal training in fundamental sciences was unusually good for his day and place, and yet who for years after the time he was legally qualified to practice the profession of medicine, was so buffeted by the circumstances of fortune—the burning down of his school property in La Porte, the loss of his claim where afterward was erected the city of Duluth, the financial stringency following the panic of 1857, the failure of the country around Le Sueur to develop according to general expectation, the advent of the Civil War with its terrible strain on the pioneer settlers in southern Minnesota—that despite his unusual qualifications and his utmost efforts yet was barely able to support his family. In many respects this part of his history reminds us of a like period in that of Ulysses S. Grant. When some measure of prosperity began to arrive in Rochester and the surrounding county, after the Civil War, despite the fact that he was then forty-six years of age, his breeding, his education, and his training in adversity gave him at last the opportunity to be of great service to his community. His determined purpose, his ripened judgment, his rare skill, and his fertility of resource made him an outstanding surgeon of his time and place, a broad physician and a powerful and much respected citizen of his state. Not the least of his services to humanity was, taking heed from the grievous delay of his own opportunities, that he began their training for the profession of medicine at the earliest age of his two gifted sons, William James and Charles Horace Mayo.

LOUIS B. WILSON, M.D.

IACOBI BERENGARI

Carpenſis

Chirurgia olim in Bononienſi Academia Profeſſoris celeberrimi.

DE

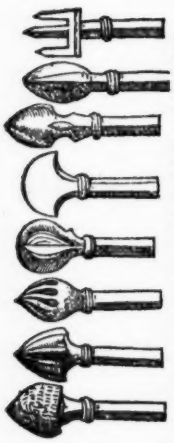
FRACTVRA CRANII

LIBER AVREVS.

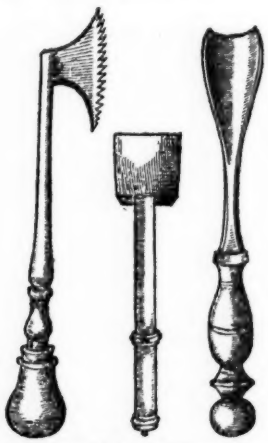
Hactenus deſideratus.

Editio nova, ab innumeris mendis vindicata.

LVGDVNI BATAVORVM,
Ex Officina IOANNIS MAIRE.
clɔ Iɔ. c. xxix.



Sunt præterea octo aliæ ſpecies ferramentorũ, hic ut vides, depictorum quæ itidem *terebra* appellantur, inque eodem receptaculo (hoc eſt, in primo inſtrumento) ponenda ſunt, prout videtur operanti. Formam cujuſlibet ſpeciei vides hic. Porro, ut prius dixi, de qualibet ſpecie ad minus ſunt habenda quinque inſtrumenta; ſcilicet minima, parva, media, magna, & maxima. Sciat vero Chirurgus ex iſtis octo inſtrumentis non niſi quinq; apta eſſe ad operandũ, ubi eſt prius aliqua fiſſura in cranio, propter ipſorum formam rectam linearem. Namq; linea recta ferramẽti eſſet in directo fracturæ præcipitaretur cum ſupra pãniculos, &



Sunt ultra prædicta inſtrumenta alia quatuor, ut hic videbis, quorum unum eſt ad formam ferræ, quæ a lateribus eſt aſpera, rodens ultima, ut hic vides.

Alterum ferramentum dicitur Scalprum rectum, ſive Scalpellus, eſtque aliqualiter con-

Sequitur aliud inſtrumenti quod *elevatorium magnum* appellatur: quo utimur ad elevanda oſſa depreſſa, cujus extremitas ponitur ſub oſſe, & elevatur os quantum intendit operator.

Sequitur aliud ferramentũ, quod dicitur *roſtrum accipitris*, cum quo etiam elevantur oſſa ubi opus eſt, ut hic vides.

THE SURGEON'S LIBRARY

OLD MASTERPIECES IN SURGERY

By ALFRED J. BROWN, M.D., F.A.C.S., Omaha

CONCERNING FRACTURE OF THE SKULL
By JACOB BERENGARIUS of CARPI

METHODS of warfare have always greatly influenced surgery, especially in early times when the surgical therapy practiced by the educated surgeon was confined principally to the relief of the results of trauma. Wars were very frequent during this period but these so-called wars were little more than riots or uprisings of untrained mobs of hired ruffians armed with clubs, lances, or anything they could find. Following a successful attack and capture of a castle or town, the soldiery immediately became unmanageable and the inhabitants were promptly either murdered or beaten badly and left where they lay to be buried if dead or cared for by the surgeons. The period ushered in by Lorenzo the Magnificent in Southern Italy, was also signalized by the splendor of its entertainments. When one considers that in those days entertainment consisted largely in banquets and drinking to great excess the inference that broken heads were a common sequence is not difficult to draw. The opportunities therefore for study of injuries of the skull were great and Berengarius' treatise is the result of his intensive study of this department of Surgery.

Jacob Berengarius was born at Carpi, probably during the third quarter of the fifteenth century. The son of a physician, he was early inducted into medicine and became interested particularly in anatomy in which he followed the then authority Mundinus though he did much practical work himself, for he says in the introduction to his anatomy that he had opened many hundred bodies. Also he was recognized by Gabriele Fallopius as the greatest anatomist up to the time of Vesalius. He pursued his early studies in Rome where he met and gained the patronage of Albertus Pius, Count of Carpi. Desiring further knowledge in anatomy and surgery he went to Bologna and there obtained his doctor's degree. His continuous studies and successes in his work gave him a great reputation as a surgeon particularly in skull injuries for he was sent for from different parts of Italy to consult and operate on this type of case. When he operated upon Lorenzo de Medici, Duke of Urbino, who had been injured at the storming of the castle of Mondalfo, it seems that a piece of bone slipped between the skull and dura and he did not have the proper instrument with which to get it out, but he goes on to say "Nevertheless the Grace of God aiding, the bone was drawn out and health restored." Berengarius achieved the notice of many of the great men in Italy for he is mentioned by Vasari and Benvenuto Cellini, and held in his part of Italy a position comparable to that of his contemporary, John de Vigo who practiced in Rome. He was given the professorship at his alma mater at Bologna and this he held from 1502 to 1527. He then went to Ferrara and probably died shortly after 1530.

Though Berengarius was celebrated as an anatomist and also as one of the first to use mercury by inunction in syphilis, his major fame rests on his work in injuries of the skull. The treatise first appeared in 1518 carrying the title "Tractatus de fractura calve sive cranii a Carpo" etc., and was reprinted at various intervals in amended and amplified form for nearly two centuries, the last edition appearing in 1715. The edition illustrated is one of the most complete, that of 1629 entitled "The Golden Book concerning Fractures of the Skull of the most Celebrated Jacobus Berengarius of Carpi at one time Professor of Surgery in the Academy of Bologna. Hitherto desired. A new Edition freed from many errors."[1] According to both title and preface the book was hard to get for the writer of the preface says—"We give you, benevolent reader, this book of Jacobus Berengarius concerning fractures of the skull, a work up to the present seldom seen but desired by many." As it had gone through three editions up to that time it must have been one of the most outstanding authorities to require reprinting over a hundred years after its first publication. Berengarius divides his work into two major parts; the first, the causes from which the names and types of fracture come. For example he enters into a discussion of the fracture by contre coup. The second part treats of the symptoms, prognosis, and treatment of the different types of fracture and illustrates the instruments used and types of trephining. These parts run one into the other and at times both are discussed together so the divisions are not distinct. He refers to the great authors of antiquity and cites their opinions, often with praise and always with respect. A little study of this book will only increase the reader's admiration for the amount of knowledge that Berengarius had been able to acquire.

[1]Courtesy of the Library of the College of Medicine, University of Nebraska, Omaha, Nebraska.

REVIEWS OF NEW BOOKS IN SURGERY

A *VADE MECUM*[1] of the clinical aspects of syphilis has appeared which takes its rank as one of the outstanding contributions to medical literature during the present year. The qualifications and experience of its author, Dr. Stokes, require no comment.

The book furnishes a long, but until now an unfulfilled, need of every student of medicine whether he be a general practitioner or specialist in that it furnishes a clinical background for the understanding of the disease. In its correlation of the protean aspects of the disease it stands as an unique and original contribution to the field of syphilology.

The author has adopted and consistently followed an admirable plan for the presentation of his subject. The first five chapters deal with the fundamentals of diagnosis and treatment. There are seven chapters alone on the actual treatment of the disorder, and great care has been taken to include in a logical way every detail, from the drawing of blood for a Wassermann to intraspinal therapy.

The newer preparations, bismuth and tryparsamide, are fully discussed as are the dermatological aspects of syphilis.

There are complete chapters on syphilis of the bones, the cardiovascular, nervous, and gastro-intestinal systems, and special chapters on syphilis of the liver and spleen. Familial and prenatal syphilis are discussed thoroughly. The book is replete with some five hundred excellent photographs, illustrative of cases and conditions noted in the text.

Much emphasis has been placed on the early recognition of the disorder and to that end, the technique of a dark field examination, the Wassermann reaction, and the value of routine spinal fluid examination. The high standard which the author sets may not be reached by all who undertake the treatment of this disease but nevertheless it will serve as a goal.

All in all, it is a monumental work and its general reading will do much to stimulate the profession to a higher plane in the detection and treatment of this widespread malady.

EDWARD A. OLIVER, M.D.

THE treatment of chronic catarrhal deafness[2] is unsatisfactory and disheartening. There are several causes for this. The range of hearing of which the ear is capable far surpasses the range necessary for voice perception, so there is possible a considerable loss before the hearing for voice is affected and it is chiefly with this that the patient is concerned. Again with good perception present in one ear the patient often disregards even a serious loss in the other. So it often happens that the deafness is well advanced before the sufferer comes into competent hands, and the otologist is faced with fixed pathological changes which it will be practically impossible to correct. The pathogenesis of some cases of chronic progressive deafness is not clear. Accordingly any method, no matter how empirical, which promises to restore even a modicum of hearing is to be enquired into if vouched for from a reliable source. The reader of Dr. Cathcart's book is convinced of the earnestness with which his work has been carried on and so inclines to listen with attention to what he has to say, especially as he states that he has benefited by this treatment.

The method of Zünd-Burguet is based on an attempt to re-educate the hearing sense. It is not claimed that it is a curative agent, only that it will alleviate. There are two essential factors. The primary current of the electrophone produces sound vibrations of varying intensities through the range of hearing from 80 to 3,500. These sounds conveyed to the ear by a telephone receiver are of a quality resembling those of the voice and their amplitude can be varied. At the same time a second current transmits a gentle disturbance of the air which produces a vibratory massage "of the whole auditory tract." What is meant by this latter statement is not quite clear. That vibratory massage can be produced in the conducting mechanism is recognized and used, but a vibratory massage "of the whole auditory tract" extending as it does to the temporal lobes, the reviewer finds difficult to visualize. The method is said to be beneficial in nerve deafness and in all forms of conduction deafness, including otosclerosis and chronic catarrhal deafness. The full course is 30 sittings and 12 at least are necessary before a prognosis regarding possible benefit can be given. When improvement results it lasts as a rule from 6 to 9 months and then another course is required.

The treatment produces some curious results. While the hearing for voice is markedly improved, that for whisper is relatively little improved or not at all. "However much the patient may improve for the voice, his range of hearing remains the same for the tuning-forks. The watch and acoumeter I consider useless tests for any practical purpose in these cases, and never employ them; in fact I have had to advise patients not to use their watches for testing their hearing several times a day, and have explained to them that whether they heard the watch—or thought they did—better or worse, was of no importance from one point of view, as the voice was the only important thing to hear; but it was important from another point of view, because if they thought they did not hear it, they worked

[1] MODERN CLINICAL SYPHILOLOGY; DIAGNOSIS, TREATMENT, CASE STUDIES. By John H. Stokes, M.D. With the co-operation of Paul A. O'Leary, M.D., William H. Goeckermann, M.D., Loren W. Shafer, M.D., and Cleveland J. White, M.D. Philadelphia and London: W. B. Saunders Company, 1926.

[2] THE TREATMENT OF CHRONIC DEAFNESS BY THE ELECTROPHONOÏDE METHOD OF ZÜND-BURGUET. By George C. Cathcart, M.A., M.D. New York: Oxford University Press, 1926.

themselves up into a nervous state which had a bad effect upon their hearing." It is acknowledged that the personality of the experimenter bulks largely in the treatment. The arguments for and against are fairly stated but leave one unconvinced in regard to the merits of the method.

That the organ of hearing can be re-awakened in some cases of deafness the reviewer has no doubt. The results would appear to show that much of the gain has been in educating the central receptive mechanism to an increased acuity.

The book is very readable and the chapter on respiratory exercises after adenoid operation is worthy of thought. Dr. Cathcart does well to insist that it is not sufficient to remove adenoids which bar the respiratory passage and directly or indirectly affect hearing; the respiratory mechanism must be re-educated. However, the exercises he gives are very elaborate and might well be simplified.

J. Gordon Wilson.

THE third edition of Dr. Mackenzie's book on heart affections,[1] which summarizes his clinical experience, is worthy of the high reputation of its author as a teacher and original thinker. It is not a comprehensive presentation of the subject of heart disease; rather it is a concise exposition of the more practical aspects of cardiology. The book is characterized by its common sense and will be of most value to the men who want helpful suggestions for daily practice. Subjects about which controversy centers are presented from the author's viewpoint with almost no reference to other authors or other theories. What is here contained obviously bears the stamp of a great personality, and is frankly presented as the result of a ripe experience.

The author has not found the various tests of cardiac function useful or even interesting. It is his opinion that "the standard for estimating the heart's strength is found by ascertaining the response of the heart to effort. The standard by which the heart's strength is to be measured is not a fixed standard; it will vary with each individual examined. The field of normal response to effort varies widely in different healthy individuals."

The chapter on the anginal form of heart failure is a presentation of the views which have been associated with the name of the author for two decades or more. "The pain of angina pectoris can best, for practical purposes, be considered as an expression of exhaustion of the heart muscle, generally from insufficient blood supply."

It seems that the discussion of the cardiac irregularities would be more illuminating if these were illustrated by electrocardiograms instead of polygrams. The latter are more difficult to read and are certainly no better understood by American physicians. From the purely clinical side the discussion of auricular fibrillation is excellent. Theoretically, the author dismisses the theory of "circus movement" with the verdict "not proven" and still adheres to the view that the stimuli, which during fibrillation of the auricle control the ventricle, arise in the auriculoventricular node. The chapters on murmurs and diastolic murmurs are among the best in the book. The classification of murmurs as physiological, functional, and organic should help to remove much of the present confusion regarding the significance of murmurs. The physiological murmurs are defined as those which "may be present in hearts which are perfectly healthy in every respect." From the physiological murmurs the functional murmurs must be separated; the latter are found under conditions which imply some derangement of the cardiac muscle.

Apparently the authors accept the view that digitalis has an essential diuretic action other than that due to improved circulation, renal and general, associated with the action of digitalis upon the heart. This is not in accord with current teaching.

The book is attractively printed and the subject matter well arranged. It can be highly recommended for its practical value, especially to the general practitioner. It is informing, concise, and clear and should prove of real value to those who strive to apply the advances of modern cardiology in their daily practice.

James G. Carr.

THE lectures[2] given on the invitation of the Universities of Barcelona and Madrid by the well-known Italian physiologist, Professor Giulio Fano, have been collected and translated. The book is not a technical treatise on the physiology of the brain and heart, but a broad, philosophical, speculative, and artistic interpretation of the author's scientific data obtained through experiments on the physiology of the brain and heart. After discussing the relation of physiological data to living matter, he arrives at the conclusion that "there is no living matter, but there are materials organized and utilized by the will to live." While discussing inhibition and will, excitability and automatism, he points out that physiology is not merely a natural science, but is also "a fount of moral instruction worthy of consideration and of imitation." The translation of Helen Ingleby is so excellent that none of the spirit of the original has been lost. Anyone interested in biology will find the book easy to read, interesting, and stimulating.

A. C. Ivy.

THE subject of the surgical treatment of gastric and duodenal ulcer seems at the present time to be in a rather chaotic state. It reminds one of the controversy on the surgical treatment of gallbladder disease a decade or more ago. The question of cholecystectomy vs. cholecystostomy seems to be settled for the present. Now the great question is—shall a gastrectomy be done for chronic peptic ulcer

[1] Principles of Diagnosis and Treatment in Heart Affections. By Sir James Mackenzie, M.D., F.R.S., F.R.C.P., LL.D., Ab. and Ep., F.R.C.P.I.(Hon.), and James Orr, M.B., Ch.B. 3d ed. New York: Oxford University Press, 1926.

[2] Brain and Heart: Lectures in Physiology. By Giulio Fano. Translated by Helen Ingleby. Foreword by Prof. E. H. Starling, C.M.G., M.D., D.Sc., F.R.S. London and New York: Oxford University Press, 1926.

and a duodenectomy for a duodenal ulcer? Men of wide experience differ very materially. Finsterer, von Haberer, Moynihan, and others are exponents of radical surgery, while Sherren, Walton, Paterson, Balfour and others still favor conservatism. A study of their statistics is interesting as each can prove excellent results with his own form of treatment.

Pannett[1] in a recent monograph attempts to clarify the matter. The author summarizes the present-day information on etiology, pathology, and symptomatology of peptic ulcer and after quoting other surgeon's opinions, gives his personal deductions as to treatment. He is inclined toward radical surgery since it is the reviewer's opinion that the removal of the duodenum for an adherent ulcer is the most radical type of surgery. The author favors sleeve resection or the Pean operation for gastric ulcer and, excepting rather vague contra-indications, duodenectomy for duodenal ulcer. The observations and remarks on perforation and hæmorrhage are interesting.

In the light of some recent observations, a word of warning should be voiced, since in a high percentage of cases in which an extensive stomach resection has been done, a severe type of anæmia has developed. Attempts at more conservative surgery should be made, since the removal of a large segment of the gastro-intestinal tract is not economically sound. It is the reviewer's opinion that we are substituting technical surgical dexterity for deeper study into the cause of peptic ulcer, its effect on function and its mechanism of symptom production.

JOHN A. WOLFER.

IT would appear that in America, the surgery of childhood is not stressed to the extent that it is in England and yet the children in England or on the continent probably receive the same or not as good care as they do in America. General economical conditions play a vital rôle in determining the outcome of all diseases of children. Wholesome and uncontaminated food, sunshine, and good hygienic conditions play an essential part in the welfare of the healthy as well as of the sick child. So far as the reviewer knows, no medical school in America gives a specific course in the surgery of childhood; but many surgeons who hold staff positions in hospitals for children give this subject its proper place in teaching. The surgery of childhood is peculiar in that the infant or child is subject to certain diseases the subjective symptoms of which cannot be ascertained because of the absence of speech or the lack of co-ordinate thought.

Fraser, in his recent two volume work,[2] gives to the surgical profession the specific information which he has acquired in the treatment of surgical conditions in children. He attributes much of his success and knowledge to Sir Harold Stiles, his teacher, a pioneer in pediatric surgery, to whom he dedicates his work.

The author aptly states in the chapter on general considerations: "The activity of the growth and development of children has a powerful influence upon disease. It is this which renders children liable to be affected by slight causes, and makes disease sudden in its onset, short in its course, and intense in its symptoms. This influence is especially important in relation to the nervous system; for the activity of this system in healthy children often causes a trifling illness to assume an aspect of the greatest gravity, while the nervous depression which accompanies chronic wasting diseases may so obscure symptoms that a dangerous intercurrent affection may appear trifling or may remain altogether latent." Further on he states: "The clinician will do well to remember that the inarticulate expression of disease in infants possesses one outstanding advantage—it is honest. An infant's philosophy may be summed up in the statement, 'All that is painful is evil, while all that is pleasant is good.'" These statements sum up much of the fundamentals of the surgery of childhood.

The author depends in a measure upon the reader's general knowledge of surgery and the other special branches of medicine, and includes those facts which are peculiar to childhood surgery or those procedures and deductions which present variations from adult surgery. The chapter on fractures is brief but lucid. The chapter on tuberculosis of bones and joints is comprehensive, clear, and concise yet brief. Surgical rickets is unusually well covered. Some disappointment might be voiced in the brief way in which the surgical conditions of the neck and face are described. The same may be said of empyema.

When one considers the tremendous amount of material to be covered and the plausibility of omitting facts which are common knowledge to the general surgeon, it would seem that the author has given to the profession a very valuable and compact monograph on the subject of the surgery of childhood.

JOHN A. WOLFER.

[1] THE SURGERY OF GASTRODUODENAL ULCERATION. By Charles A. Pannett, B.Sc., M.D.(Lond.), F.R.C.S.(Eng.). New York: Oxford University Press, 1926.

[2] SURGERY OF CHILDHOOD. By John Fraser, M.C., M.D., Ch.M., F.R.C.S.E. vols. i and ii. New York: William Wood and Company 1926.

Fig. 10. Case 3. Left lateral film taken on patient's admission, disclosing huge frontal aerocele originally mistaken for a cholesteatoma. Arrows point to small osteoma regarded merely as a coincidental finding. (Print reversed, and reduced ⅓.)